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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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SCHOOL SCIENCE AND MATHEMATICS

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WHAT SHALL WE TEACH?

A few years ago great educators said the subject matter was of little consequence so long as the mind was disciplined. More recently we have been importuned to teach the useful; but, since this does not sufficiently limit the field, "the relatively useful should be taught." Guided by this or by some other equally potent ignis fatuus and urged on by popular applause we have deleted and eliminated with little regard for anything but immediate utility. One result is that many people are desperately trying to do things for which they are entirely unprepared and our professional schools are filled with students woefully lacking in basic knowledge. One phase of this condition was well stated in the following editorial reprinted by special permission from *The Saturday Evening Post*, copyright 1929 by The Curtis Publishing Company.

THE KEY OF THE UNIVERSE.

Mathematics, if we are not greatly mistaken, is presently destined to play a much larger part in our general scheme of education than it ever has in the past. One is forced to this conclusion not by the insistent demands of students but by the consideration that the tools and the methods offered by this science have been so largely responsible for the extraordinary advances in other sciences which the past generation has witnessed. The more mathematics contributes to the development of other sciences the more dependent upon it they become.

This state of affairs has come to such a pass that already the layman who wishes to keep up with modern thought is restricted to the use of the most elementary books, for if he goes to the more advanced works, the sources of really sound and substantial information, he at once finds his progress barred by an entanglement of calculus and other branches of higher mathematics which he either has not studied or has completely forgotten.

In electricity, physics, chemistry and astronomy the educated reader might expect to encounter this difficulty, but he may be surprised to find that he will be no better off if he attacks biology, physiology or any serious discussion of the structure of matter, of the nature of the atom, or of modern conceptions of time, space and what we call the universe. It is as

if a new and untranslatable language had suddenly come into common use among our real intellectuals and we must for ever remain cut off from knowledge of the amazing and thrilling doings in the learned world about us, simply because they can only be described in that language—a strange tongue which it would take half a lifetime to master and which no man can render into plain understandable English.

We hark back to the sixteenth century as having been one of the most colorful in all history, because all the Old World was agog with the discovery of the New. For a hundred years the wild tales and rumors which drifted eastward across the Atlantic and were talked over and retold by round-eyed burghers in every inn and alehouse made high and low feel that they were living in a continuous fairy tale full of wonders, monsters, and strange happenings. It was, in truth, a mighty century; and yet there are those who, without belittling the achievements of the early voyagers, will declare that the discovery of the land beyond the sea was as nothing when set alongside certain recent explorations of our boundless but finite universe and the discovery of the countless little universes which are as numerous as the atoms themselves. One difference is that though we laymen suspect that something of supreme importance has been going on around us, and epoch-making discoveries have been made, our Columbuses and Einsteins have not brought back from the jumping-off places of the universe any golden nuggets or aromatic spices or exotic living creatures as understandable trophies of their voyages. About all we can learn from the lofty and slippery wall of ignorance which confronts us is the conviction that we know little or nothing about time or space or even the electricity which we buy so freely at a few cents a kilowatt hour.

There is, of course, a practical answer which should perhaps silence these lamentations of ignorance. We shall be told that if our modest intellectual equipment causes us to funk these higher jumps which Mr. Einstein and other scientists have set for us, there are plenty of others within our powers. There is always bridge or contract or even chess; and every newspaper has its syndicated crossword puzzles and so-called brain teasers.

This vigorous snub should perhaps put in their places those humble learners who want to learn for the sheer thrill and pleasure of learning and knowing; but it does not answer those practical souls who are beginning to realize the extent to which mathematics is invading every field of everyday life. It does not answer the youngster who wants to build bridges or skyscrapers and knows that he must mix higher mathematics with his mortar, build it into his foundations, and use it to test every I beam and angle iron that goes into his work. It does not answer the young research physician or biologist or chemist or industrial engineer who knows that he cannot reach the top of his profession owing to his lack of advanced mathematical knowledge. It does not answer him who has discovered, or thinks he has discovered, that higher mathematics is the master key of the universe.

There are still those who suppose that this untranslatable language we call mathematics is as dead as classical Latin or Sanskrit. They have no one to tell them that it is as truly a living science as physics or chemistry; that new and startling advances in it are still being made every few years, and that with every day that passes it becomes more and more interwoven with our daily lives and with familiar things of which we make daily use. Industry recognizes, in a measure, its debt to this science. Our larger electrical and telephone companies have fostered it consistently, and in recent years farsighted insurance companies have thought it worth their while to support mathematical research.

Every circumstance points to the belief that if we are to keep up with the procession of human progress our schools and colleges will have to devote more time to this subject; offer more advanced courses and stress their importance to every student who hopes to make any real progress in the physical sciences.

WHY A BOOK LIST AND BOOK REVIEWS?

Each issue of School Science and Mathematics contains a list of new books with name of author, name of publisher, size and cost. The recognized position of this Journal as the leading journal for teachers of all branches of science and mathematics enables us to make this list practically a complete catalog of new textbooks in this field. In addition, the list includes many supplementary and reference books. This list gives teachers a convenient means of keeping informed on new publications and provides publishers with the most economical means of announcing new books.

Lack of space prevents reviewing all books listed and limits detailed reviews. Those selected for review are the ones most likely to be in greatest demand by our readers and those others which give promise of being outstanding contributions to education. In general these reviews are made by our regular department editors. They have all made special preparation for their particular branches of science and in addition they are successful teachers with long teaching experience and training in the science of education. Their aim is to give tersely and accurately the most prominent features of the book, so that the reader may gain a fair idea of its plan and contents without further examination. This results in economy of the teacher's time and, if used by all, will assist in reducing cost of publication. One of the important problems of publishers is admirably stated in the June, 1929, issue of *Ohio Schools* under the title "Your Friends, The Publishers" which we here reproduce.

There has long since ceased to be any doubt about the constructive services of the textbook publishers to public school development. The day of questionable methods in the marketing of textbooks has also for the most part slipped into the limbo of forgotten things. Publishers are still the most potent force in curriculum development in America in spite of a generally awakened interest in this activity on the part of educators. The friendly attitude that uniformly exists between buyer and seller in the textbook business is a praiseworthy condition.

But publishers are sometimes thoughtlessly imposed upon by teachers, and a word needs to be said in this connection. The bane of the business is the terrific drain in the giving of free samples of textbooks. Perhaps publishers were originally at fault in encouraging this practice, but in fairness to them teachers ought now aid in checking the practice. Textbooks could be sold at lower figures if this item of selling expense were materially reduced. And the teacher does hold much of the power of improvement in her own hands.

Publishers are glad to have teachers manifest enough interest in some new publication to write for a copy, but why should the teacher expect to get that copy without paying for it. Frequently there is no possibility whatever of its being considered for general use, but it is sent for merely because the teacher thinks it might be of value to her. In no other line of business would that same teacher expect to get a full-sized package of a

product that interested her, although samples are sometimes offered. One cannot write for a tire for the automobile and expect it to be sent gratis on the theory that, if satisfactory, it may be adopted for all four wheels. Even a box of face powder cannot be obtained with the maker's compliments in the hope that by thus submitting it he may gain an exclusive five-year contract. Why should the publisher's wares be regarded so differently? If the teacher wants a copy of a new text, the equitable thing to do is to send along the money to pay for it. Or, because administrative heads of school systems are generally expected to be in touch with the newest materials, she can probably obtain a copy from the superintendent's office for such inspection as she wishes to make; or she can ask to have a representative call. Publishers will never escape the necessity of supplying samples to school executives or teacher committees which are definitely charged with the duty of specific text adoptions, but they ought not to be subjected to indiscriminate requests.

The self-respect which makes us unwilling to step into a store and ask a merchant to give us an article off his shelves ought to govern us in our relation with textbook publishers. Let us be just as alert and responsive to publishers' announcements as ever, but let us play the game in a broadminded way by paying for what we want. Free book samples are not a proper perquisite of the office of teaching.

ANNUAL MEETING OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

Progressive teachers of science and mathematics should plan to attend the annual meeting of the Central Association which will be held at the University of Chicago, November 29 and November 30. At its annual meetings the Association gives teachers excellent programs, both stimulating and informing. It also offers opportunities for becoming acquainted with other teachers, many of them leaders in science and mathematics. By exchanging ideas with new and old friends one gets inspiration and suggestions, both so necessary to successful teaching.

All programs this year promise to be exceptionally good. Recognized leaders in the fields of science and mathematics have been secured as speakers. The annual dinner will be given on Friday evening, November 29. It will be followed by an address of merit.

Every possible effort is being made to have the meeting stimulating and pleasant. There should be a large attendance.

LECTURE-DEMONSTRATION VS. INDIVIDUAL LABORATORY WORK.

This topic is one of vital interest to all concerned with the teaching of science. On page 730 of this issue Professor Croxton has more to say on this subject. The two previous articles in this controversy published in our January and April issues were made the basis of a very interesting discussion by two veteran science teachers, Mr. Frederick E. Sears and Mr. John C. Packard, at the 112th meeting of the Eastern Association of Physics Teachers held at Phillips Academy, May 4 and published in the report of that meeting.

HIGH SCHOOL GEOGRAPHY—TO BE OR NOT TO BE.

By Nels A. Bengtson, Ph.D.,

Professor of Geography, The University of Nebraska, Lincoln, Neb. President, National Council of Geography Teachers.

In order to appreciate the present status of geography in the high schools of the United States it seems advisable to summarize first some of the larger movements which have characterized the subject during the past half century. Prior to 1892, geography held an important position in the educational scheme up and to including the high school. Its content, however, was purely descriptive, and emphasis was given its locational phases. Pupils were drilled in locations of multitudes of towns, rivers, bays, gulfs, mountains, peninsulas, and capes. *Where* seemed to represent the key note of the geographic study of that period. Map questions galore featured the textbooks. When the generation which had been taught under the standards of description and location reached positions of leadership in the educational world there was revolt against the whole scheme because of the dryness and grind of the subject. The idea became prevalent that geography should be more philosophic in character and that the idea of *why* should be stressed.

One of the great milestones in the development of geography teaching in the United States was the work of the Committee of Ten of the National Educational Association whose report was presented in 1892. The Conference on Secondary School Geography took a stand for a deepened and broadened course in earth science. Its brochure, presenting lucidly the arguments in favor of the change from the descriptive and locative to the philosophical, gave impetus to a radical departure from the earlier content of geography and to marked change in the methods of presentation. The report of this committee was the crystallizing force which led to the "what, why, and what of it" of modern geography. Its recommendation that physical geography be given in the first year of the high school course led to the almost universal introduction of that subject as a basic science requirement. That *physical* geography was pushed into the position of responsibility was due to the fact that those who were espousing the cause of geography were then almost without exception, geologists who had become impressed with the significance of physical environment in relation to human development. It is not surprising that they placed physical features rather than man in the center of the picture.

In 1897 the Science Section of the National Educational Association appointed a committee of nine to consider the problem of *physical* geography in secondary schools. The very fact that a committee of this character was appointed was an indication that the subject as taught was not meeting the demands that educators were placing upon it nor was it giving the results expected of it. This committee made its report in 1898, the key-note of which was that "The subject should be carefully held to the leading idea of the physical environment of man." Physical geography thus seemed to be securely anchored in the course. Textbooks and laboratory manuals multiplied at a rapid rate, and steady improvement marked the succeeding years. Equipment for teaching physical geography was provided along various lines and schools increased their material facilities with relative rapidity; nevertheless dissatisfaction grew.

Ten years later, in 1908, the Science Section of the National Educational Association appointed another committee and charged it to report upon "The Essentials of a Course in Geography for Secondary Schools." It was noteworthy that in this instance nothing was said about *physical* geography. In the same year the Association of American Geographers in session at Baltimore appointed a committee charged with the same purpose. The N. E. A. Committee was headed by J. F. Chamberlain; among its membership were Professors R. H. Whitbeck and Mark Jefferson. This committee reported at length on the status of the subject and evaluated the dissatisfaction which was then recognized. Changes in the course in high school geography were recommended on the grounds that

1. Too much emphasis was being placed upon the study of land forms and too little upon the human responses to those forms;

2. The study of the relationships between human activity and environment was neglected;

3. Geography was being taught as a college entrance subject rather than from the standpoint of aiding the student in pre paring to meet the obligations and opportunities of life;

4. Physical geography as taught failed to give the student a grasp of the natural resources, industries, and commerce either nationally or internationally;

5. Geography in the secondary school failed to give reason-

able attention to any phases taught in the elementary school, a condition which produced discontinuity in subject matter where continuity should exist and ignored the development of proficiency in the fundamental aspects of the subject;

6. Physical geography did not give the student the knowledge of the regions and peoples of the world which intelligent participation in the affairs of life requires.

The six points thus outlined were a severe indictment of geography as taught in the high schools of the United States in the period preceding 1910. Geographers early recognized the situation and their views as expressed in educational journals were prophetic of the change to come. Professor Dodge, then editor of the Journal of Geography, repeatedly pointed out the danger of over-emphasis of the physical aspects, and the neglect of the human relationships. Under his leadership the members of the Association of American Geographers devoted a full evening at the 1908 meeting in Baltimore to a round-table discussion of the subject of secondary school geography. At this conference the subject was handled in scientific manner; its present status, character, advantages, disadvantages, the needs of high school pupils, the content of the most valuable course and the possibilities of such a course were all formulated, labelled, and catalogued in systematic order. The net result however lay in the recommendation that "high school geography should deal largely with regions—say, the United States and Western Europe." This was concisely stated in a report published in the Journal of Geography, February, 1909, "Such a course would best, perhaps, be divided into parts; (1) physical geography in which only those phases of the subject should be included which later will be needed and they studied so as to suggest their application, and (2) regional geography in which given regions are studied systematically from the larger topics of position, surface, climate, etc. to a climax in economic and social phases."

The Committee of Seven of the Science Section of the National Educational Association presented its report in July, 1909; this was published in the Journal of Geography in September of the same year. The findings of the committee were presented in detail; in essential respects they were in harmony with the results of the Baltimore conference of the Association of American Geographers. The "*piece de resistance*" of this report consisted of a platform of 8 main planks, the first four of which dealt

with mathematical geography, climate, oceans, and earth forms, thus showing that physical geography was at least making orderly retreat—it had not been routed. The fifth plank was a plea for a study of the natural resources of our country, the sixth for general geography of the most important countries and peoples of the world, the seventh for some conception of how the history of nations has been shaped by geopraphic conditions. The final plank was stated as a major objective, viz. that the study should develop in students "the ability to trace, in the large, the relationships between the most important geographic forms and geographic processes, and to appreciate the responses which human life everywhere makes to its physical surroundings." The program thus broadly outlined was indeed an ambitious one.

The Committee of Seven made specific recommendations for the attainment of its program. In brief these were that (1) Geography should be a required subject in all secondary schools, (2) the subject should be carried for not less than one year with five recitations per week, (3) about one-fourth of the total time should be devoted to laboratory and field work, and (4) the final, specific recommendation was that about one-half year should be devoted to the larger topics in physical geography, with the human side made prominent, and that the remainder of the year should be given to a study of the United States and Europe. This was a notable report prepared by an able committee and presented to the annual convention of the largest educational organization in the world.

Nearly 20 years have elapsed. The report has joined the illustrious hosts of the past and the development of the course in secondary geography has proceeded as tho there had been no report. Physical geography survives but its position in educational scheme is but a shadow of its former self. It has been humanized but somehow the operation has left it weaker than it was before. Commercial and industrial geography continue to hold their places in commercial curricula, but their cultural value is restricted by the ever-conscious demand for practicability; the relative position of even these phases of geography has probably not been strengthened during the past two decades.

It is well-known that since 1908, physical geography has been almost completely displaced by general science. From a position of undisputed supremacy as the introductory high

school science it has been reduced to a minor position; probably, not more than 10 or 15 per cent of the schools now include it in their curricula as required work. Commercial geography is taught in 60 or 70 per cent of the schools but only in the commercial courses. A survey, by no means complete, indicates that regional geography is given in not more than 4-5 per cent of the high schools of this country, and it seems to be about on a par with so-called *general geography*.

An interesting aspect of the present situation is that geography, where taught in the high schools, is a subject of long standing in the curriculum. An inquiry addressed to 100 representative schools in the United States was answered by 58 of them. In 52 of these schools some geography was offered, but in only one of the number had it been introduced recently. It seems clear that such rank as geography now holds as a high school subject is due in large part to tradition rather than to accepted value.

The recession of geography as a high school subject has been due to various causes. Physical geography was given its golden opportunity through its recognition by the famous Committee of Ten, but failed to make good on it due to its inherent quality as a highly specialized subject for which he preparation made had not been adequate. Educators soon came to feel that the introductory work in science should be of broader appeal than was provided in physical geography, hence its displacement by General Science. There is no reason to expect any decisive swing away from this position.

General Science will undoubtedly be modified but the changes will probably be limited to refinement in detail and not such as to lead to displacement. It is an exploratory study well adapted to the needs of pupils of Junior High School age. Its extensiveness causes it to be ever-challenging to precocious young adolescents. Geography should contribute effectively to the General Science program and geographers should earnestly cooperate in supplying high quality of subject matter in this field. In such spirit General Science should be greeted as an introduction to Geography, as valuable in that respect as it is to any other high school subject.

But in some other respects the decline of geography has been based on false premises. Geography deals with affairs of such every day occurrence that, by educational administrators, it has become identified as belonging to the commonplace. The

idea of learning its facts and even its philosophy *incidentally* in connection with other studies has become ingrained in the minds of those in the seats of the mighty. That, in some mysterious manner, it may be learned without direct, intensive study has become a common notion. Geographers have long been convinced of the falsity of this view but so far have found no means of counteracting it. Those handling underclassmen courses in colleges fully appreciate the woeful ignorance in matters geographic of high school graduates. In a test involving recognition of the states as shown on an unlettered outline map of the United States given to 227 beginning students in geography at the University of Nebraska in the fall of 1928, only 10 made perfect scores; 30 named 45-47 states correctly; 46 named 40-44 states correctly; and 98 failed to name correctly one third or more of the states. The median of the entire number identified only 36 states of the forty-eight.

In order to test to what degree the geographic background of American History was being developed through history teaching, a list of 65 questions was submitted by the Geography Department of the University of Nebraska to 932 high school pupils studying American History, in 36 schools of the state. This list had been criticized by specialists in the Teachers College and by two of the professors in the History Department. Only such questions had been retained as had received the unanimous approval of all the critics. We believe that every question was reasonable and fair. Twenty of the questions were of the multiple-choice type, five answers being suggested for each and the student required to choose. The second twenty questions were of the "true-false" type, and the final list of twenty-five could be answered each with a word or two.

In the first list, that of the fivefold multiple-choice type, the score showed 35.7 per cent of the number answering correctly. Inasmuch as 20 per cent represents probable score on a basis of pure guessing only a residue of 15.7 per cent of the answers are left as being entitled to be classed as proven knowledge—surely not a creditable score. Illustrative of the types of errors a few samples may be cited: Only 17.3 per cent of the answers correctly recognized the Champlain Valley as located between the Green Mountains and the Adirondacks; almost as many said it was between the Green Mountains and Blue Ridge. Over 50 per cent of the pupils failed on the problem of the location of the Fall Line. Only 27 out of 932 pupils

correctly named the location of the western terminus of the Mormon Trail—561 had it extend into the Sierra Nevada Mountains! To a question asking for the *physical barrier* that helped most to make for unity among the colonies in the War for Independence, 517 named "hatred against England!"

In the true-false list, out of 18,640 answers, 9,271 were correct and 9,369 were incorrect, thus giving rise to a score less than zero. The participants were not even good guessers!

In the third set the general average of the results was somewhat better but even so the score was only 25.5 per cent. Only 43 out of 932 answered correctly the question, "The Dutch early settled in what good east-west gateway to the interior of the continent?" Only 30 per cent of the papers gave correctly the name of the city located near the falls of the Potomac River. To the question, "Canals were constructed in Ohio to connect the Great Lakes with what river?" 43 per cent of the participants gave correct answers—a high score. On the other hand only 30 pupils of 932 asked gave correctly the name of the natural region of Pennsylvania in which soft coal is mined.

For the test as a whole, the score was about 20.4 per cent and this makes no deduction of the fraction due to guessing on the first set. This inquiry was not carried on with a large enough number to be conclusive but the results are clear indices of existing conditions. That the results would be about the same in all parts of the country is highly probable, altho there would be some variation in detail. But the fact remains that to a list of 65 carefully selected questions, 932 high school students in American History in grades XI and XII wrote 60,580 answers and that only 21,869 of the number were correct. Geography, fundamental in American History, is not being mastered in connection therewith, and *it seems clear that teaching it incidentally must therefore bear the stamp of failure.* Geography demands intensive mental application for its mastery, and its importance in a scheme of liberal education is such as to deserve the necessary time and talent for such mastery. The failure of methods now followed calls for a change and it seems to me that the time is ripe for a forward move.

Educators and business men alike are taking definite stand in favor of such lines of work as will prepare students to become intelligent interpreters of modern conditions. There is general recognition of the value of the social sciences—modern and current history, economics, government, and geography. The

last named is fundamental to the others. If geography is to occupy the place now open to it a positive, constructive program must be offered that will be practical under present conditions and be responsive to the appeal of superintendents and the public. The situation presents two phases both of which must be met, viz. the general and the commercial courses of the high schools. With respect to geography, the prevalent opinions among educators appear to fall into four main groups, viz.

1. Those who favor geography as a basic study fundamental in commercial and general high school courses without regard to specialization.

2. Those who favor a semester of introductory general geography with emphasis on the fundamental principles of human interest, and that to be followed by a semester of commercial or regional geography depending on the course of study selected by the student.

3. Those who believe that the geography of the general and commercial courses should be distinctly differentiated from the beginning.

4. Those who do not believe that geography is desirable in the high school course of study.

These are the major groups and all are sufficiently important that their positions must be respectfully met. Courses must be so wisely planned and material of such value prepared, that the first three will have their desires satisfied. It is then probable that the success attained will cause the fourth group to disappear.

For the general course choice must be made between two major alternatives, viz. (1) give one semester to a study of fundamental geographic principles and follow it by a semester devoted to regional studies, or (2) introduce the regional study of North America at the outset and follow it by summarized studies of the other grand divisions or by more detailed studies of Europe and Latin America. In the latter case the fundamental principles would be developed in connection with the various regions rather than first abstractly developed and later followed by concrete applications in regional studies.

In commercial Geography, work of encyclopedic type will not survive. Students are not receptacles into which knowledge can be poured as water into a jug. Emphasis must be placed on thinking and reasoning and the facts presented in given lines of study must be considered to be, essentially, working tools in the

stimulation of mental processes. In order to accomplish this, the lines of study must be limited to the barest essentials, and these should be presented as types rather than as embracing the whole field of human knowledge. Commercial Geography should not, however, become provincial, nor limited in its scope to those resources and industries which are only of direct concern to the home locality, altho some emphasis thereupon is quite sound educationally because of its value in stimulating interest. If a study can be so organized that it will lead to an appreciation of the fundamentals of modern industrial and commercial life, it will also lead to a sympathetic and intelligent attitude toward world problems. This is an ideal that should be kept in the foreground in considering any educational program and at no time has its importance been greater than it is now.

The problem is before us. I believe that the opportunity for progress is at hand, but to move without having a carefully considered program to present would lead in the wrong direction. First, a fact finding survey needs to be conducted on an extensive scale. Are the aspects of geography which are essential for intelligent citizenship now being taught in the high schools of the United States? Is *incidental* teaching of geography as now carried on reasonably successful? While geographers may be fully convinced regarding these propositions they lack the evidence wherewith to prove their case. After obtaining the evidence, it must be presented in concise form through the medium of the educational press, and to the organizations of school executives of the country. A searching survey for facts and then effective publicity for such facts is the first needed move. This must then be followed by the presentation of a carefully worked out, constructive program of achievement to be presented and defended in the councils of those in charge of determining the educational policies of the country. High school geography is now the missing link in the sequence from elementary school to college and university. For the future, "To be or not to be?" is a question which should be answered by a response in accordance with the educational value of the subject.

For the year ending June 30 the Federal Government paid thirty states a total of over $1,600,000 as their share of national forest receipts. This sum, which is a payment in lieu of taxes the states would receive if the national forests were privately owned, must be used for schools and roads. California receives the largest sum and Oregon is second.

MAKING THE CONCRETE AND ABSTRACT HELP EACH OTHER IN MATHEMATICS.

By Fletcher Durell,
Belleplain, N. J.

It is a familiar fact that abstract concepts and general principles when rightly used are often great savers of labor and are otherwise important sources of efficiency.

Thus when a child is learning his number facts, after realizing, for example, that 2 marbles+3 marbles = 5 marbles, that 2 apples+3 apples = 5 apples, that 2 splints+3 splints = 5 splints, it is desirable that he learn as soon as possible that 2 strokes (on the blackboard)+3 strokes = 5 strokes (when a stroke may stand for any special kind of concrete object), and thus rise to a grasp of the general notion that, as we say, $2+3 = 5$; this meaning, of course, that 2 units+3 units = 5 units, the units being alike in any given case. If the pupil were required to do without this general concept and to learn this relation for every special kind of concrete object met with by him, the labor involved would be practically without limit. So for each other special number fact.

In like manner, for examples, in getting the areas of triangles, it is important as early as possible to obtain a general rule and formula for the area of all triangles.

Hence we may say broadly, that the right use of general ideas and principles saves time, labor, and expense, and enlarges life as a whole in many ways.

It brings certain comprehensive advantages which are not fully evident at first sight. For the grasp and use of such concepts and principles makes it much easier, in fact may be essential to such a process as reducing a large collection of data to order and system. It enables a person to rise out of a vast welter of detail to an elevated point, whence he can get a comprehensive view of the situation, to organize the large number of details into a system, and to use them according to a definite plan. As the world life increases year by year in extent and complexity and the field of knowledge includes an ever greater number of special facts and items, the value of general laws as economizers and organizers in like manner continually advances.

Hence it is not surprising to hear a thinker like William James say that abstract ideas are like seven-league boots that carry us along in our thinking with magical ease and speed. In like manner Plato said "the man who will show me the one in the many I

will follow about like a God." Perhaps it is not too much to say that the power to make and use abstractions is the chief superiority which man has over the lower animals.

But it is also a familiar fact that there are serious dangers and drawbacks connected with the extended use of abstractions. In mathematics if reference to concrete meanings and practical applications be omitted too long, processes become empty and meaningless to the pupil, and in fact may become a mere juggling with symbols. To many students, these processes not only cease to have any appeal, but become, in fact, distasteful and repulsive. Even if agreeable, an almost exclusive use of generalities tends to turn out mere theorists instead of practical, everyday workers and thinkers.

So great in some cases have been the abuses and drawbacks that have arisen in connection with the use of abstractions in education, that in recent years several movements have developed having for their object to put a large part, if not all, of education on a concrete basis, Such, for instance, are the Case Method, the Project Method, and several features of the so-called Progressive Education.

In all such procedures the first and main subject matter is supplied by a series of concrete activities like keeping a store, running a school bank, laying out a tennis court, or writing and producing a drama. The principles of such a subject as arithmetic are to be a by-product and more or less incidental result of such activities. Often what we may call a comprehensive theory or grasp is not arrived at.

But as had already been indicated such primarily and fundamentally concrete education is so full of multitudinous detail that it is extremely expensive of time, money, and strength, while not reaching any inclusive and thorough result. More than that, it is apt to produce in the pupil's mind the impression that material, concrete things are the main element in life, and thus tend to make our civilization materialistic. Also, protracted avoidance of the abstract is likely to weaken and soften the pupil's mind. Judicious use of general ideas strengthens, stretches, and toughens his mental fiber. Active cooperation of abstract principles and concrete illustrations does this better. With over 25 million children to educate, and with a daily increasing mass of concrete detail to learn to handle in our even more complex civilization, with an even greater need of system, order, and idealism, there is an increasing need for

the use of highly efficient general methods and principles.

Hence it is the view of this paper that in present day education it is desirable as soon as possible to rise to and employ general ideas. In presenting the subject of geography, the wise teacher usually begins with objects familiar or easily accessible to the pupil, as the nearby lake or pond, island, river, hill, mountain, and city. But instead of continuing to use for years only such piecemeal surroundings, the teacher as soon as possible leads the pupil to the conception of the entire earth as a ball or globe, after which all special detailed geographical facts are filled in in relation to this comprehensive concept.

In other studies the wise method is to follow this same plan as far as possible. This is especially true of mathematics. For mathematics, dealing as it does with number, space, and quantity is by its very nature essentially an abstract science. But in its presentation and study, while general concepts and principles should dominate, concrete illustrations and applications have an extremely important role. It is the object of this paper to make suggestions looking, if possible, to a more efficient cooperation in mathematics of the two elements, the abstract and concrete.

Systematic Recurrence to the Concrete.

In the first place, then, in dealing with abstract ideas and laws, especially when teaching young children, it is important to recur frequently and even systematically and periodically to the concrete meaning and uses of these general ideas.

Thus in teaching a number fact like $4+7 = 11$, we of course, at first show what this means by the use of splints, marbles, or other concrete counters of some sort, and later drill the pupil on the relation or bond in its purely abstract form. As has been remarked, if this purely abstract drill is continued too long, the real meaning of $4+7 = 11$ tends to fade away, and the whole exercise becomes a mechanical and empty juggling with the marks, 4, 7, and 11. To prevent this as well as to give vivid appreciation and to sustain interest, it is well for the teacher to return occasionally to the form //// + /////// = ///// ///// / or to have the pupil do this; or even to illustrate the fact by more concrete counters. The same sort of procedure applies to the teaching of carrying when adding numbers or borrowing in subtraction (where splints tied up in bundles of tens may well be used). The use of diagrams to illustrate $\frac{3}{4} = 6/8$, $\frac{1}{2}+3/8 = 7/8$, and like facts concerning fractions are other applications of

the method under discussion. We repeat, these concrete devices are to be used not merely once by way of introduction, but are to be recurred to periodically according to the needs of the class or of the individual pupil.

Similarly in studying algebra we cause the pupil to return occasionally to a realization that, for example, $x^3.x^2 = x^5$, is an abbreviation for (xxx). (xx) = (xxxxx); that x^0 is a special way of writing the result of dividing x^n by x^n; that x^{-2} may arise from $x^3 \div x^5$; and so on.

It is of especial importance by this method of recurrence to help the pupil keep in the background of his mind, the meaning of short cuts and processes such as cancellation, transposition in solving equations, the clearing equations of fractions, and short forms of multiplication and division. When dealing with a type of short multiplication such as $(a+2b)$ $(a-2b) = a^2-4b^2$, the method to be used is of course occasionally to require the process in hand to be performed in the long as well as the short way. It is also helpful in such cases to have the pupil form the habit of making a rough estimate of the ratio of the amount of labor in the long process to that in the short process.

Similarly we recur occasionally to the meaning of certain definitions and terms, as to the fact that a decimal fraction is a short way of writing certain common fractions; that the term "per cent" has various aspects of meaning, and in fact often a specially useful substitute for a common fraction, decimal, or ratio; and that the ratio concept in like manner has various meanings. Completion and other new type tests are especially useful in this connection.

Occasionally the end here desired may be attained by using ordinary language instead of a technical term, or by using the two together in dual form as when we write "integers (or whole numbers)," or "binomials (or two-termed expressions)."

Taking up another aspect of the matter, it is of course obvious that in teaching abstract, mathematical principles according to the plan here being presented, the practical, everyday applications of each law or principle should be taught in close connection with this principle.

But if the views here advocated are fully carried out, the recurrent use of practical problems will be extended further than is usual and developed in forms and ways not now customary. It is at present the standard practice in a text-book to give formal drills and applied problems in entirely separate exercises. In

the writer's opinion the two types of work should be more closely interwoven than is customary. Wherever possible a few, if only one or two, very simple and direct applications of a principle or formal skill should be given at the end of a formal drill on that skill. So a good chapter or other general review should be a mixture of the two kinds of work. Myers (see SCHOOL SCIENCE AND MATHEMATICS, March, 1928, p. 285) makes the following suggestive remark on this point: "It is safer, more economical, and more readily administrable and supervisable to maintain the old skills chiefly through scientifically constructed drills, each of which shall contain a sampling of verbal problem units, placed at short and roughly regular intervals, throughout the work of the school year." This idea applies of course to arithmetic, algebra, and geometry alike. In the early study of mathematics, the concrete application should always, if possible, be within hailing distance of the principle.

In this connection it should be stated that a good project is a useful and efficient way of showing in a synthetic manner, the practical uses of an aggregate of formal principles and for this reason may well be usually placed in the middle or at the end of a chapter. But the topic of projects is so large that it cannot be fully discussed in this place.

Graphs also form a convenient and useful way by which to recur to the concrete, when dealing with abstract principles and processes. To get full benefit from graphs in this respect, the treatment of them should be broken up into progressive parts and these parts inserted at approximately regular intervals.

The value of various kinds of diagrams when used as a help in the solution of verbal problems and mensuration examples should also be mentioned in this connection.

In this matter of the regulated alternation of the abstract and concrete, it is to be noted that there is a certain amount of relativity as to what constitutes the concrete as distinguished from the abstract. Thus what is at first abstract to the child or immature mind, may by long use and familiarity take on some of the qualities and acquire some of the pedagogic values of the ordinary everyday concrete. Thus, after much use, the so-called abstract numbers like 12, 18, etc., as compared with the algebraic symbols for any number, as n, x, etc., assume a certain aspect of tangibility or semi-concreteness and become helpful in making algebraic expressions clear, firm, and meaningful in the pupil's mind. An example of this relative concrete is the numerical

application of a formula in algebra as composed with the formula itself. So in proving and discussing geometric theorems, these should frequently be illustrated by special numerical cases.

Ordinary words are more concrete than the single letter-symbols used for them. Thus $(area) = (length) \times (width)$ is a more real and tangible statement than $A = lw$. In the preceding pages other special forms of the semi-concrete, that is, of the abstract which has taken on a concrete flavor, have been used such as the use of strokes for units, the meanings or definitions of certain terms, and the efficiency explanation of mechanical rules or processes.

In recurring to the concrete or the everyday realities of pupils, frequently two or more kinds of concrete can be combined in a single case with especial effectiveness, as when concrete problems and diagrams for them are used together.

Before concluding this part of the discussion it is important to make one or two other observations.

Besides the co-operative alternation and other systematic interrelations of the abstract and concrete in the text book used, a certain supplementary initiative and resourcefulness on the part of the teacher are desirable. Some pupils need or would profit by a much more frequent reference to the concrete than others. Also what is concrete to one type of mind is not so to the same degree to another, or perhaps not so at all. Special emergencies are constantly arising calling for special methods. Research and close observation and the devising of appropriate procedures will not only be highly profitable but will also tend to prevent monotony and to create zest for the day's work. Opportunities will also be afforded in each teacher's daily work for the discovery of results of wide and general value.

In like manner it should be observed that the frequent recurrent use of the concrete when studying generalities given variety and spice to the work for the pupils, helps to sustain and increase their interest, and perhaps may create a higher order of pleasure in the work.

The functional interrelations of the different branches of elementary mathematics, viz: arithmetic, algebra, and geometry, which characterize co-operative mathematics, if that method of study be used, frequently supply mass recurrences to the concrete. For arithmetical numbers are more concrete than algebra and certain parts of geometry, and geometry than certain parts of algebra and arithmetic.

Thus in many ways a periodic recurrence to the concrete is a prime aid in utilizing to the utmost, the giant economizers and efficientizers which we call abstractions.

Kinds of Approach.

Thus far in this discussion it has been assumed as natural and normal that the approach to a new principle should be through the concrete. But whether this method is always best or not, is a matter of such importance that it should be discussed by itself in some detail.

The ability of most children to grasp and to some extent use general or abstract ideas is usually greatly underestimated. Many of the child's earliest activities are of a general or, from one point of view, abstract nature. For instance, all observant parents have noticed the pleasure which a creeping ten-months old child takes in opening and closing a door or drawer, or, when in a high chair, in repeatedly dropping an object and watching it fall to the floor. Such activities are prophetic and general in nature, so far as their actual use is concerned. The powers thus gained have no present, immediate value, and are to be put to a practical concrete use later.

So an older child often prefers the solving of puzzles to working in the garden. Thorndike some years ago conducted an interesting and valuable investigation as to which kind of example in algebra pupils like most to solve. The test given included formal examples in abstract processes, verbal problems about concrete facts, examples based on simple data in engineering, and so on, the list being made extensive enough to cover every main line of appeal. The test was given to a large number of both girls and boys, and in a variety of schools. As an outcome it was found that the decided preference of both boys and girls was for the solution of a pair of simultaneous equations like $3x+2y = 11$. This of course is a purely formal, abstract process. The preference thus expressed seemed to be determined by a realization of and pleasure found in the superior efficiency of the process; that is, the power, with relatively small exertion to produce a result simple and exact in form, which in no way could have been predicted, and which was easily verifiable, and hence was certain and sure.

Some leading philosphers as Plato, Kant, and Hegel, maintain that human beings are born with certain innate ideas, as of numbers, space, time, etc., and all must admit that in very young children capacities for such lie very near the surface.

A writer in the American Mathematical Monthly (March, 1919, p. 95) suggestively alludes to the "often forgotten principle of psychology which declares that in youth the mind is open, and indeed eager to receive idealistic rather than material truth."

Hence it would appear that if anything like speed, inclusiveness, and power, can be gained by a semi-abstract, or even abstract approach to a subject, such introductions should be used more often than is now customary.

Certain specific details concerning this topic call for special mention. Thus, in case the concrete approach is used, great care must often be exercised in selecting the best kind of concrete to employ. For example, at one time it occurred to the writer that on entering school pupils in the first grade could best be taught the primary number facts by the use of apples.. Apples are plentiful in September, and they are a familiar object to both city and country pupils. What was simpler than to show and say (2 apples)+(3 apples) = (5 apples), and what would have a more direct appeal? But a practical first grade teacher pronounced the scheme unsound for the reason that such objects as apples have too many and too decidedly distracting associations. The sight of the fruit creates a desire to eat it and causes the mind to wander by raising questions as to where the apples came from, where they may be obtained, what is to be done with the apples on the table after the school is closed, and like matters of association. Hence this teacher preferred to use other objects with less appeal like splints or pebbles.

In like manner it is evident that any difficult technic in a preliminary concrete illustration is to be avoided. In all such cases a simple form of semi-abstract is desirable.

Again, if the project approach is used, sometimes the same project, with some modification in each of its successive appearances, can be used recurrently in introducing several topics that follow each other. The effort of mastering a new illustration for each case is thus avoided, and the repeated but varied use of the same project becomes like the chapters in a story.

If the concrete, preliminary illustration is carefully chosen it may be made not only a means to the revelation of the new principle to be mastered, but also a rough review or summation of the work of past grades, and a keynote or bridge to those that follow.

In case the more abstract method of introducing a new topic is used, those methods in which the efficiency of the new process

is made evident are especially satisfactory. Examples of this are the use of an abstract or formal equation like $3x-2 = 7$ (not a verbal or concrete problem) in showing the meaning and use of transposition in solving an equation; or of an expression like $(a+2b)$ $(a-2b)$ in introducing the topic of abbreviated multiplication; or the computation of the numerical value of terms like $\frac{1}{\sqrt{5}}$ and $\frac{1}{5}\sqrt{5}$ when teaching the meaning and value of rationalizing the denominator of a radical expression.

The enlistment of the self-activity of the pupil in every kind of approach is desirable, but is particularly important and valuable in cases where this approach is along abstract lines. Thus when the object is to show that $\frac{6}{8} = \frac{3}{4}$ by means of a circle divided into sectors, the pupil should be asked to draw such a circle and make the inference from the same, or to do some similar exercise as a part of the inductive study.

Since no one particular kind of approach can be used in all cases and since a certain best method, adapted to each special topic, must be sought, there is here room for valuable observation and research on the part of the teacher and all concerned. The teacher should often supplement and vary from the textbook. Such adaptations are not only important and valuable in themselves but will add to the work, new elements of interest and attractiveness, both for the teacher and pupil.

Some Arithmetical Applications.

One more matter may be appropriately discussed in connection with the general theme of this paper. This relates especially to the use of so-called abstract number and concrete number in connection with the processes of division and multiplication in arithmetic.

Some writers and textbooks assert, for example, that it is impossible ever to have a concrete number as a divisor of another number. Others maintain the contrary and in supporting their position distinguish between two kinds of division, called, respectively, partition and measurement. They go so far as to elaborate a considerable technic in the use of these two species of division. It may be well to recall that of the two following examples in division the first is a case of so-called partition, and the second of measurement:

$$\text{Ex. 1.}\quad \begin{array}{r}\text{6 apples}\\ 3\overline{)\text{18 apples}}\end{array}\qquad\qquad \text{Ex. 2.}\quad \begin{array}{r}6\\ \text{3 apples}\overline{)\text{18 apples}}\end{array}$$

As has been said some pedagogists regard the form of solution used in Ex. 2 as wholly inadmissible. They would work the example entirely by the use of abstract numbers, thus $\begin{array}{r}6\\ 3\overline{)18}\end{array}$. With regard to the form of solution given in Ex. 1 above, the strict constructionists would prefer to use the following $\begin{array}{r}6\\ 3\overline{)18}\end{array}$ $\therefore$ 6 apples. Ans. In this method the given concrete numbers, 3 apples and 18 apples, are first stripped of their concrete shells or qualities, and made into the abstract numbers, 3 and 18. The operation is then performed with these abstract numbers. Then the concrete shell is re-attached to the result of the abstract process.

So in converting 15 ft. into yards the following different forms are used by various teachers:

$$\begin{array}{r}\text{5 yd. } \textit{Ans.}\\ \text{3 ft.}\overline{)\text{15 ft.}}\end{array}\qquad\qquad \begin{array}{r}5\\ 3\overline{)15}\end{array} \therefore \text{5 yd. } \textit{Ans.}\qquad\qquad \begin{array}{r}\text{5 yd. } \textit{Ans.}\\ 3\overline{)15\qquad}\end{array}$$

In like manner the question arises in finding the area of a rectangle 8 in. long and 5 in. wide, whether it is proper to write 8 in.x5 in. = 40 sq. in., or whether we should use the form 8x5 = 40 $\therefore$ 40 sq. in. *Ans.*

Similarly if the example is to find the number of feet in 4 yd., the question is which of the following ways of expressing the process is allowable or is to be preferred:

$$\begin{array}{r}\text{4 yd.}\\ \underline{3}\\ \text{12 ft.}\end{array}\qquad\qquad \begin{array}{r}\text{4 (yd.)}\\ \underline{3}\\ \text{12 (ft.)}\end{array}\qquad\qquad \begin{array}{r}4\\ \underline{3}\\ \text{12 ft.}\end{array}\qquad\qquad \begin{array}{l}4\\ \underline{3}\\ 12 \therefore \text{12 ft. } \textit{Ans.}\end{array}$$

As a means of getting light on these questions we first observe that Ex. 2 above (the illustration of the measurement type of division) may be expressed as a verbal problem as follows:

"A woman has 18 apples. To how many children can she give 3 apples each?"

She might solve the problem by giving 3 apples to one child after another till the apples are exhausted; that is, by successive subtractions from the 18 apples which she has. But division is abbreviated subtraction. Hence it seems perfectly proper to use the concrete number, 3 apples, as a divisor in the form used in Ex. 2 above.

As a matter of fact, all of us, children and adults alike, have

more or less unconsciously formed the habit of using abstract ideas cooperatively in connection with concrete, everyday problems. Many times, perhaps hundreds of times, each day, without giving the matter special thought, we take concrete data that come up, strip them of their concrete clothing, qualities, and associations, swiftly and efficiently operate with the resulting abstract residues, and then tack on or attach to the abstract result, the proper concrete properties or clothing. Owing to these swift, informal, subconscious habits which pupils have formed and practiced till they have become a part of their very mental texture, most pupils have an invincible repugnance to using the elaborate, technical, formal, and uniform procedure usually prescribed. Such pedantic formalism most of them will not take the trouble even to understand. It raises difficulties in their mind where there were none before. It is a clog and hindrance in their thinking instead of an aid.

The wise thing seems to be first to make sure that the pupil understands the process in hand; to let him use the process of taking off and putting on the concrete shell, largely unconsciously according to his already acquired habits; and to allow him large freedom as to the particular written forms which he employs for expressing his work. Let some use one form and some another according to their individual preferences.

Advantages.

Some of the benefits which may naturally be expected from the interwoven and cooperative use of the abstract and concrete here advocated have been mentioned incidentally in the preceding pages. In conclusion it may be well to collect and tabulate these advantages and if possible add other items to the list.

1. As compared with more strictly concrete methods, this cooperative procedure means a large saving of time, and an ultimate economy of effort on the part of both teacher and pupil, and a better final organization of subject-matter.

2. As contrasted with more purely theoretical procedures, it safeguards against the errors and drawbacks connected with mere empty formalism. It gives definiteness and clearness as well as comprehensive organization.

3. The frequent repetitions involved, both of abstract and concrete at regulated intervals, tend to fix permanently the meaning and values of each of the two partner elements.

4. The alternations used give variety and spice to the work, and therefore help create a more intense and sustained interest.

5. It breaks up theory into unit parts easy to assimilate, and helps prevent or remove the otherwise frequent dread and dislike of abstract theory.

This also gives the power to use theories and abstractions in a partial way for what they are worth in any particular local connection. It frees us from pedantic formalism of many different kinds.

6. It stretches and expands the mind, and gives a tougher mental fiber, and a more thorough mental organization than could be obtained by narrower methods.

7. It induces a habit of mind which is an important aid of a special type of education which is of great value in certain situations and which is being increasingly used. The method followed in this form of education is to alternate book work and shop work for certain periods of time as for half days, weeks, or even semesters. Examples of schools and institutions which follow this method are Hampton Institute, some high schools in Cincinnati, Antioch College, Massachusetts Institute of Technology, and certain schools for adolescent boys in Boston.

8. The habit and power of using the concrete and abstract in cooperative combination, if acquired in one field, has a wide application elsewhere. If attained in the study of mathematics, it can be used in the study of physics, ethics, economics, art, and religion, and in each special domain of both everyday and cultural life. For instance, in every field, the most enjoyable and usually most profitable reading is that which, in skillfully interwoven form, combines concrete incident and illustration with a certain amount of general philosophy of life.

Hence summing up in a single sentence, we may say that a method of study like that outlined in these pages adds not only to the practical and vocational, but also to the ideal and spiritual values of mathematics.

"CHILDREN" BECOMES "THE PARENTS' MAGAZINE."

The name of "Children, The Parents' Magazine" has been changed to "The Parents' Magazine." The policy of the publication will remain unchanged.

Among the institutions officially interested in the magazine and cooperating in its publication are Teachers College, Columbia University; University of Minnesota, State University of Iowa and Yale University.

As heretofore, the editorial content will deal exclusively with (1) The care and training of children from crib to college, (2) Family relationships and home life, (3) The management and equipment of homes in which there are children.

LIVING PLANTS AVAILABLE IN WINTER.*

By L. H. Tiffany,

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Some one has defined biology as the "study of dead specimens—the deader the better." Now if that be our conception of biology, there is no excuse for a paper of this title. A professor of the humanities in one of our large universities observed a class in botany looking at certain shrubs and trees on the campus and later exclaimed with apparently alarmed surprise, "Why, I saw a class in botany studying plants out-of-doors!" (Perhaps he added despairingly, "What is science coming to!") If this point of view prevails to any extent regarding biology, a paper of this kind may not be wholly amiss.

Perhaps the most important question the teacher can ask himself is "What is the aim of my botany course anyway?" Judging from the assortment of general botany texts on the market just now, one is driven to the conclusion that not all botanists are of one accord as to the correct answer to this question. This rather general eruption, even if no conclusion be agreed upon, is, however, a very healthy educational omen. It indicates that some botanists feel the undesirability of continuing the genealogical endemism of I-must-teach-as-I-was-taught kind of botany. Did you ever sit in a laboratory during a summer quarter and count the nuclei in an embryosac or stipple in the protoplasm of a cell "at least five inches in diameter" (laboratory directions), when outside the window trees were in full leaf, herbs were in bloom, and the campus creek had a flora different from that on the upland? If so, perhaps you too have asked yourself, "Why have a general botany course?"

The aim of an elementary course should be thought of with certainly some attention given to the student and what benefit he will derive from it. What can the teacher honestly hope that the student will carry away with him? Will he (or should he) remember very long the difference between the sporophyte and the gametophyte of a moss, the dichotomous venation of a Ginkgo leaf, or the theories of cellular development? Or should he go away with such general conceptions as: green plants manufacture their own foods out of raw materials, respiration is essentially the same in plants as in animals, plants in winter are not necessarily dead because there are no leaves? I shall not pursue

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the matter further than to say that what one *can* do in the winter with plants depends considerably upon what one *wants* to do; *i.e.*, upon one's idea of the aim of such a course.

Dr. Miller in the May number of this Journal has presented some data on out-of-season material possible among animals. I shall attempt to outline a similar procedure with the use of plant materials. The outline used below is not organized from any particular point of view, but it is hoped may prove useful as suggestions regarding what out-of-season materials are available among plants. Of course one must use what one has, and the teacher living along the seashore desires a different assortment from the one living inland. I am thinking particularly of the region roughly covered by the North Central States.

Algae. It almost seems unnecessary to mention aquaria for the growth of algae, but it is true that most forms of algae can be grown during the winter. If the teacher will suggest that the students bring in pond or lake water with perhaps a little mud or some sticks or pieces of seed plants from along the water's edge, a living aquarium can soon be secured. These aquaria are to contain few if any fish, else the algae will soon be eaten. The algal forms may be largely plankton, but the mud or sticks may contain spores which will germinate and produce filamentous forms. The aquaria must be ample in size for sufficient aeration, must be kept in moderate light and under normal growing temperatures, and should preferably be replenished upon evaporation by water from out-of-doors, not tap or city water. Aquaria rich in organic matter will develop bluegreens as well as the green algae.

Many large filamentous algae like Cladophora in running water, species of Oedogonium and Spirogyra under the ice or in protected places along the water's edge, and Vaucheria around springs are perennials. These may be had in a fresh condition nearly any day in winter. Some students get great enjoyment out of keeping certain algae in the dark for some time in nutrient solution, and then watching how soon photosynthetic activity and subsequent appearance of oxygen bubbles occur upon sudden illumination.

In this connection mention might be made of the microcosm. There are many types in use. A simple one can be set up with a five-gallon carboy (used for distilled water) into which has been placed a pint or so of soil, a couple of gallons of water, some aquatic plants (as algae, elodea, or eel grass), and a goldfish.

Some experience is required to know the quantity of plant to use to make a balance between the two organisms and the environment. The apparatus can then be sealed, set in moderate light, and watched for some time by the class. It makes an admirable, living demonstration of the interrelations of plants and animals as regards gases, foods, energy, minerals, etc.

Mosses and Liverworts. Except when the ground is covered with snow, certain mosses can always be secured from woods and along stream banks or even in most lawns. Others are available on the bark of trees and on rotten logs. The sporophytes produced in autumn often remain throughout winter. Similarly moist cliffs and rocks are nearly always covered with Conocephalum or some other thalloid liverwort and even with the "leafy" forms, although the latter are more difficult to find. Terraria are easily constructed for both liverworts and mosses, care being taken to screen out the bright light and to keep the humidity of the chamber rather high. Marchantia of course is a common greenhouse form found growing on the moist soil the year round. In this way one can often have in the winter the material necessary for a complete life history of such plants. And to see the living material in conjunction with such preserved and microscopic material as is necessary is an infinite boon to successful teaching.

Fungi and Bacteria. One can always have the children get a piece of stale bread, moisten it, inoculate it with dust, and place in the dark. Quite soon the bread mold, together with green and blue molds, will appear on the bread. The water mold which often destroys fishes can be had by dropping some dead bees or flies in pond water and waiting a few days. During the winter, pore fungi can always be found on trees, dead logs, and stumps in the woods. If the school provides a dark cellar, perhaps the class can grow its own fungi. An excellent account of how to grow mushrooms may be had from a recent bulletin of the United States Department of Agriculture (Farmers' Bulletin No. 1587). Cultures of yeast are easily made from a cake of yeast, purchased at the market. Alcoholic and acetic acid fermentation may be demonstrated by such cultures. By use of a thermos bottle containing a thermometer this same culture can be shown to release energy in respiration. The release of carbon dioxide from the yeast plants can be noted by a tube running into lime water.

A piece of rotten wood split open or leaf mold gathered from the forest will show the living vegetative hyphae causing decay.

Ripping off the bark of a decayed log will readily reveal the same growing hyphae.

Bacteria readily develop in hay infusions or in sugar solutions exposed to the air for a few days. Of course yeast and bacteria are perhaps in-season all year round, but their demonstration in winter is sometimes supposed to be more difficult than in summer. Iron and sulphur bacteria are available quite frequently in near-by springs or "seeps." Crowns of red clover plants showing bacterial nodules on the roots may be obtained any time during winter.

Ferns. Potted ferns are present in nearly every home, and some forms are to be found all winter in protected ravines of deep woods. If one places the spores, growing in dots on the under sides of the leaves, on a moist surface kept moist, one may easily grow a crop of fern prothallia showing the sex organs. Close relatives of the ferns, the horsetails and club mosses, are usually available during winter, and the latter plant can be grown very well indoors.

Seed Plants. If one becomes accustomed to looking for plants in a vegetative state during the winter, he will be agreeably surprised at the number located. Our common dandelion blooms every month of the year in many localities. The closely appressed leaves of the rosettes of many other plants such as evening primrose, fire weed, teasel, mullein, and winter cress can be found rather readily. Even such supposedly spring plants as the hepatics keep their leaves during the winter. Common plantain found in all lawns makes excellent material for the study of leaf epidermis. Blue myrtle is an evergreen and its leaves are excellent for cross sectional study. Duckweeds and hornworts can be found at the bottom of ponds in winter. Rhizomes of blue grass are always available, even if one must use a mattock. Evergreen needle leaves as well as broad leaves remain on many trees throughout the cold season. The students become much interested in keeping a record, for example, of how many plants with green leaves they can find in December or January or February. Following the plants during the winter makes an excellent introduction to the rapid and phenomenal changes in dormant plants that occur upon the approach of warm weather.

Dormancy in various organs of plants is admirably illustrated in winter. The well-known winter buds of our common deciduous trees, tubers, corms, underground stems, roots, etc., are easily collected. If the class brings in to a warm room and places in

water such stems as Japanese quince, Forsythia, apple, or in fact most any woody plant, he can observe the opening of the buds, some forming flowers, some leaves and branches, and some both. In early winter the time required for forcing the buds is several weeks, but grows less as spring approaches. Seeds of all kinds are avilable for planting in soil in boxes, thus giving the class an opportunity of studying germination and growth of the seedling. Potatoes will usually "sprout" any time during the winter, illustrating the development of another kind of bud, the "eye" of the potato. If some of these potatoes are allowed to grow in the dark, while others are placed in the light, some interesting differences can be noted.

If the class can be permitted to have window boxes filled with soil in which to plant seeds or place cuttings of geranium, coleus, or other greenhouse plant, some very interesting growth phenomen can be observed. As the plants grow, one of the first things noticed is that the young stem "bends toward the light." (It is hoped incidentally that the teacher does not explain this as the "stem reaching for light.") These same plants can be used to illustrate, with simple apparatus and chemical supplies, the fundamental processes of food manufacture and use of food in the organism. If one likes a bit of the unusual, one can easily grow in a battery jar containing water with a pH about 5 (which is fairly acid) a collection of bog plants: sphagnum, cranberry, pitcher plant, sundew, etc. A supply of elodea, eel grass, pondweeds, or chara may be kept during winter in near-by ponds or pools, or in large well-lighted aquaria.

Young and mature pistillate pine cones may often be obtained during the entire winter. Early stages of the male cones may be found in terminal buds. Both male and female cones ("Juniper berries") may be found on the red cedar all winter. While gathering these, one may find "cedar apples" of apple rust. By placing the "apples" in a moist chamber at room temperature the gelatinous spore masses may be forced.

If planted early enough, one may watch such plants as beans or buckwheat come into bloom, not only giving fresh flowers, but also furnishing an excellent introduction to the formation of seeds and fruits. In fact the whole process can be traced from the opening of the flower buds to the mature fruit. Apples forced into bloom make an interesting study in connection with the fruit. Skunk cabbage blossoms may be found in winter if one will but dig in the swamp for them. Witch hazel frequently

remains in bloom during the winter. If one wants a large variety of fruits for study, one does not need to use preserved material. For a few cents there can be provided from the grocery apples, oranges, peanuts, walnuts, olives, etc. In this connection it should be borne in mind that roots of dandelion, underground stems of blue grass, or carrots from the grocery are available for dissection and study. By using the iodine test for starch, food storage can be demonstrated in bulbs of tulip and stems of ash, apple, box elder, or grape.

In the above I have not tried to write lesson plans on the out-of-doors. That is a colossal task and would require much research for accurate data regarding methods, time of year, etc. But perhaps the farther we can get away from printed directions in work of this kind, and the sooner we can get the student to begin to make observations of his own, the better off we shall be. I have merely called attention to our botanical bank account in winter. If these suggestions act in any way to stimulate further observation and study of plants out-of-doors, the paper will have been worth while.

In closing I should like to add a word in support of Dr. Miller's suggestion regarding field work in winter with the class. Nothing is more stimulating to interest (to say nothing of health) than to have well-directed observations on plants during the winter months. In fact it is well known that woody plants are as easily recognized by winter characters as by leaves and flowers. A number of keys are on the market, made upon this basis. To get the student to begin to observe is the beginning of a good observer, and perhaps also of a good biologist.

CHAMELEONIC FENCE POST.

A man's puzzlement over a fence post which he had painted black but which turned white every night was the starting point of a program of research which has culminated in the discovery of a number of chemicals having this remarkable chameleon-like property scientifically termed phototropy. Information regarding these chemicals has now been made public by the American Chemical Society.

The famous fence post was painted with a "pigment having a zinc basis." It would turn black soon after sunrise each morning, only to turn white again when darkness came. Many explanations have been given for the phenomenon, but scientists are not yet agreed as to the cause of it. They have, however, found several other substances besides the zinc sulfide, which was in the paint on the post, that will also change color with the light.

Most of the known phototropic liquids are solutions of colorless derivatives of certain dyes. The solutions are practically colorless in the dark, but turn the color of the parent dye when exposed to light.—*Science News-Letter.*

THE SPIRIT AND METHOD OF RESEARCH IN UNDERGRADUATE COURSES.

By S. R. Williams,

Amherst College, Amherst, Mass.

1. The Development of Interest in Subject Matter.

The lack of a royal road to learning should not deter anyone from seeking to improve the lanes and devious highways by which we come into the kingdom of knowledge.

How often one finds a student coming to college enthusiastic about some study and then losing that ardor during college days. Obviously a loss of interest in subject matter has occurred. Could that interest have been maintined by proper means? A conviction, growing with the years, is that the answer to this question is in no small measure related to the fact that college teaching has not kept pace with the instruction which has been given in both the public and the graduate schools. From the kindergarten to the end of the high school course the project plan is successfully practiced in the best schools. The research method, a more highly developed project scheme, is surely the method of the graduate school. Why should the four years of college work declare that the research method should not be employed in undergraduate instruction?

The project or research method is essentially a self-educating plan. As such it arouses and maintains interest in subject matter as no other method does. The research method leads a student to doing things for himself which are infinitely more valuable to him than those things which are done for him. For the sake of developing interest in subject matter, for the sake of developing initiative, are not the methods of research worthy of consideration as general methods for educating during college days?

2. What Is Research?

Research is seeking and ultimately finding the solution of an unanswered question or problem. The importance of the problem measures the value of the research. The small boy who cut open the bellows to see whence the wind came was an investigator, a researcher if you will. How valuable his work was, might be questioned. The method of research to command the respect and confidence of others must show intelligent effort applied to the solution of the problem.

The various steps in finding the answer to a question or a problem will be something like this:

I. Development of interest in some subject or thing. Letting this interest lead the imagination in the unfolding of the topic. Imagination is the soul of research.

II. Establishing theoretical answers to the many questions our mental processes bring up for solution.

III. Sifting the literature to see if anyone has already contributed to the solution of the problem. Why waste time on what has already been done?

IV. The development of strategical modes of attack on the problem. In science this would mean devising crucial experiments which would affirm or deny the theoretical assumptions made in II.

V. Where possible, confirm the results of IV by other methods.

VI. Generalization.

3. The Spirit of Research.

The spirit of research is an inate desire on the part of everyone to know in greater or less degree the reasons for things as they exist or how they behave. It is the hunter's instinct, the unconquerable spirit of the pioneer. It was a saying of Aristotle that, "All men have by nature the desire to know."

Now is all this talk about the spirit and method of research beyond the grasp and appreciation of the undergraduate? Slosson in an article on, "How Genius Works," points out that men like Newton and Einstein conceived of their most important researches during college and university days. Charles M. Hall had discovered the basic process of making aluminum cheaply before he graduated from college. If geniuses of this variety are to be encouraged, college teachers ought to be doing it. The reply to this might be that Newtons and Einsteins do not need encouragement to do their work. Doubtless there is some truth in this statement, but the fact still remains that the great centers of research are built up about great personalities who have the enthusiasm, the flair, for research and by some subtle means are able to pass it on to others. Surely genius can work better in an atmosphere of sympathy to the idea of research than it can in one of antipathy.

The majority of those who take up graduate work and so progress into their life profession, decide to do so largely on the experience of their undergraduate days. To be specific, would-be-physicists have their aspirations either confirmed or destroyed during college days. If the leaders of scientific research are really interested in the problem of stimulating scholars in research,

they will pay more attention to students in those years which are so formative.

4. The Methods of Research.

While pedagogical methods are not an end in themselves—it is the spirit which gives life,—yet methods of teaching gradually evolve in the course of years which may be helpful to others. An attempt will be made, therefore, to show how methods of research may be applied to undergraduate teaching of physics. What can be done in physics may be done in any other field. This method of educating rests upon the principle of learning by doing, whether the solution of the unanswered question is produced in the laboratory, library or study. In colonial days boys and girls learned a great deal in performing the daily tasks necessary for living. In many ways it was a great loss when modern industrial life came in and divorced learning from living.

Because of numbers the first year of general college physics is carried on in the usual way, i. e., by means of lectures, recitations and certain prescribed laboratory work. A large group may be handled by a smaller staff in this way. This is a tool course for further work in physics and should seek to give in the class-room and laboratory those subjects and experiments which are distinctively illustrative of the general field of physics. To put such a course on an individual basis would require too large a staff, because six to eight students are all one teacher should instruct.

The physics curriculum following this tool course may inaugurate the real problem and individual work, which may be extended over as many years as are desired.

In general, the advanced courses will consist of individual problems coupled with extensive reading and discussions with the teacher in charge. One's ability to handle and sift large masses of information is a great asset. The material which has been collected on most subjects is exceedingly voluminous and there is great need to be able to go over it as expeditiously as possible. The library and the laboratory are equally important adjuncts of this method. It is an attempt to develop thinkers and teach men how to find and apply knowledge.

5. Introduction of the Student to the Methods of Research

This is not a formal affair. It is a case of teacher-student co-operation. The student comes to an appointment with the

teacher at the beginning of the term. It is an hour of getting better acquainted and learning what the background of the student is. During the conversation the student will be told that there are a number of questions which might be of interest to answer. It will develop also that the teacher and student will take one of these problems and co-operatively attempt to solve it. The student will be generalissimo and the teacher will function in an advisory capacity. Once a problem has been selected the steps toward its solution should then be outlined. This outline will be very much like that already given for the general solution of a problem.

After the first conference a month or more will be spent in the library outlining the subject and partially working up the bibliography. Not only is it of value to the student, but becomes increasingly valuable to the departmental library to have the student make out a card index of the subject matter with a short abstract of the articles which have been read. Frequent conferences will be encouraged for the purpose of asking questions and getting a proper start on the problem. In these conferences especial attention will be paid to the experimental attack on the question. Gradually the student will see that among the various methods suggested by his reading there will be one, at least, adaptable to his specific investigation.

Introducing a student to this method of learning is not throwing an individual overboard to teach him to swim, with a sink or swim attitude on the part of the teacher. It is a co-operative scheme and the teacher stands by with sympathy yet in eagerness to see the would-be-swimmer strike out for himself. There will be encouragement when the going is hard and applause when the effort is successful.

The problems which may be assigned for this kind of work may be the development of new apparatus for the measurement of well known phenomena. The Editors of the Critical Tables, published by the National Research Council, suggested the measurement of certain well known physical properties of substances which are new or little known. For instance, the indices of refraction of recently developed organic compounds would illustrate this type of problem. There are problems in which both apparatus and properties must be investigated. Finally, students may assist with the teacher's own problems, even though in a modest way. This experience is often stimulating. It is related that Lord Kelvin when a young man, was sent by his

father to study under the great Regnault. Regnault accepted him as a student in his private laboratory. After some time the future Lord Kelvin complained to his father in a letter that thus far he had only held a test-tube and operated an air-pump for Regnault. The elder Thomson replied with wisdom that his son should be thankful for such an opportunity and keep at it.

> "Here work enough to watch
> The master work and catch
> Hints of the proper craft,
> Tricks of the tool's true play."

To give concrete examples of the various types of problems which have been solved by undergraduates, the reader is referred to the following papers: "Some Applications of Spark Photography," Jour. Opt. Soc., 16, p. 125, 1928; "A Short Foucault Pendulum," School Science and Mathematics, 28, p. 255, 1928; "Convenient Magnetometers," Jour. Opt. Soc., 16, p. 203, 1928.

There is no delusion on the part of the writer that these papers are epoch making, but they have had the spirit and method of research for those who labored on them.

For an expression of a student's own attitude toward this method of learning, reference is made to: "The Pursuit of Learning," School and Society, 27, Jan. 7, 1928.

A great advantage of this method is the natural selection of outstanding students. The first conference will go a long way toward classifying them. At the end of the first three weeks a teacher will have a fairly good idea of the pupils who will finish the course.

Chancellor Capen in his inaugural address at the University of Buffalo calls attention to the point of view, that, while there may be some question at present as to who should go to college, there is little question as to who should stay, provided the faculty have sufficient courage of their convictions.

The individual method of instruction, or the research method, automatically separates the sheep from the goats as no other device will. Students either do or do not take kindly to this method. Halfway measures do not seem to work. One either gets results or he doesn't. It may be that the results are negative, but results they are! This appears to be saying that students who are not imbued with the research idea are unfit to remain in college. As has already been suggested we have here

to do with a definite self-educating, and not vicarious, process. The student who shows no desire to really exert himself in mastering a subject has no place in a college. To use a homely illustration, the student who sits at a table in this sort of an educational cafeteria expecting someone to feed him is going to be left. Either he will pick up his tray and do as the others are doing or else go to another type of restaurant.

The opportunity to go to college must increasingly be reserved for those who will co-operate to make the most of it. Society should not tolerate the expense of educating those whose main idea concerning a college is that it furnishes a degree and a better entree to society in general.

6. Individual Class-Room Work.

Individual laboratory problems with their collateral reading are comparatively easy to assign, but to carry the same idea over into the class-room for that phase of work which gives opportunity for joint discussion of subject matter, needs considerable attention. One type of program may be illustrated in the following outline. It may be given to an individual as an outline of reading for him to pursue and on which to report. On the other hand this same outline may be mimeographed and handed out to a small class with the understanding that it is to be an outline of reading for all. Furthermore, it may be explained that each member of the class is expected to be prepared to take the place of the teacher and instruct the class concerning what he has read. This gives individual exercise and is instructive because one really begins to learn when teaching. If the embryo teacher may be interrupted at any point and another asked to "carry on" it may be expected that close attention will be maintained.

7. Outline.

Moduli of Elasticity.

Hooke's Law.

Stress and Strain,—homogeneous and non-homogeneous,—integral; Elements of Mech., Franklin and MacNutt, p. 163, 1907.

Elasticity of Materials; Kelvin, Math. and Phys. Papers, Vol. 3, p. 3; Encyc. Brit., Vol. 9, p. 141, 11th Ed.

Plasticity of Materials; Morley, Strength of Materials, p. 29, 1926; Shoji, Reps. Tohoku Imp. Univ., 15, p. 427, 1926; Kimball, Phys. Rev., 26, p. 121, 1925; Love, The Math. Theory of Elasticity, p. 116, 1927, 4th Ed.

Viscosity of Materials; Love, The Math. Theory of Elasticity, p. 117, 1927, 4th Ed.

True Elastic Limit, Yield Point, Tensile Strength, Resilience; Franklin and MacNutt, p. 180, 1907; Watson, A text-book of Physics, p. 202, 1920.

Elastic Hysteresis, Warburg u. Heise, Ber. d. Deut. Phys. Gesell. 17 Jahr. p. 206, 1915; Love, The Math. Theory of Elasticity, p. 120, 1927.

Elastic Fatigue, Moore and Kommers, Univ. of Ill. Bull. No. 124, 1921; Timoshenko and Lassells, Applied Elasticity, p. 460, 1925.

Young's Modulus—Modulus of Stretch, Statically; Longitudinal—Stress, Strain, Millikan's Mech. Mol. Phys. and Heat, p. 65, 1903.

Young's Modulus, by Bending, statically, Franklin and MacNutt, p. 176, 1907.

Young's Modulus, dynamically, Kimball, Phys. Rev., 26, p. 121, 1925.

Potential Energy of Longitudinal Strain, Franklin and MacNutt, p. 175, 1907.

Modulus of Rigidity. Shearing, Stress and Strain, static and dynamic methods; Millikan's Mech. Mol. Phys. and Heat, Exps. 9 and 11, pp. 71 and 87; Searle's Experimental Elasticity, pp. 90 and 95, 1908.

Bulk Modulus; Hydrostatic Stress, Isotropic Strain; Elements of Mech., Franklin and MacNutt, p. 184, 1907. Watson, A Text-book of Physics, p. 196, 1920. Searle, Exp. Elasticity, p. 6-7, 1908.

Departures from Hooke's Law, Bernoulli's Collected Papers, Vol. 2, pp. 976-989, Geneva 1744; Cox, Camb. Phil. Trans., 9, Pt. 2, pp. 177-190, 1850; Hodgkinson, B. A. A. S. Trans., p. 23, 1843. Bach, Elasticität und Festigkeit, 9th Ed., p. 105; Kelvin, Math. and Phys. Papers, Vol. 3, p. 29 and p. 82; Thompson, Amer. Jour. Sci., 43, p. 32, 1892; Searle, Experimental Elasticity, p. 78, 1908. Warburg, l. c. Crew, General Physics, p. 156, 1927; Stokes, Math. and Phys. Papers, Vol. 1, p. 75; Moore, Annual Pres. Address, A. S. T. M., June, 1928.

Books of General Reference: Applied Elasticity, Timoshenko and Lassells; Elasticität und Festigkeit, Bach und Baumann; Experimental Elasticity, Searle; History of the Elasticity and Strength of Materials, Todhunter and Pearson; Maschinen Elemente—2 Vols., Bach; Mathematical and Physical Papers, Lord Kelvin; Strength of Materials, Morley; The Materials of Construction, Johnson; The Mathematical Theory of Elasticity, Love; The Strength of Materials, Ewing.

In using an outline of this sort the student acquires habits of going to first hand sources of information and thus learns how to gain knowledge.

Individual instruction for students is exacting and burdening to teachers because it means practically as many courses as there are students. The stimulation, however, both to the teacher and the taught, is its great compensation. The great surprise to any teacher who undertakes this method sympathetically is the eagerness of the student if he takes hold of the work at all. A common experience is to find students inviting others into the laboratory to show what is being done. While not indispensable, individual work rooms are very helpful for individual problems.

To have caught the Spirit and Method of Research in one field of knowledge is to have captured them for any other field as well. Dr. Carlson[1] takes the point of view that every student "should do a bit of research in some one field as a part of his professional training, in order that the scientific method may, as a conditioned reflex, become a part of his daily thinking and behavior." Personal experience has shown that those whose life work has been

[1]Carlson, Science, 65, p. 125, 1927.

in Marine Law, in Medicine, in Engineering and, of course, in advanced Physics have returned to volunteer the information that the research work which they did in physics during undergraduate days was of immense value in their life work. So common has this experience become that there abides a very deep seated conviction that there must be some value to this method of educating.

In thus urging the merits of the research method in undergraduate days, one humbly recalls that closing paragraph of President Wilkin's first chapter of "The Changing College"; "The college is changing, rapidly and profoundly. Yet it remains constant in its intentions not merely to perpetuate but to learn and serve. And it remains constant in the certainty that methods and devices, invaluable though they be for the release and direction of power, are but the instruments of that power which lies, in the last analysis, in the warmth and light of devoted intellectual personality."

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
The University of Oklahoma, Norman, Okla.

Shun no toil to make yourself remarkable by some talent or other; yet do not devote yourself to one branch exclusively. Strive to get clear notions about all. Give up no science entirely; for science is but one.—*Lucius Annaeus Seneca, Roman Stoic, 4 B. C.*

Minds stuffed with a smattering of science may be just as opinionated as minds stuffed with a smattering of theology.—*Everett Dean Martin in "The Meaning of a Liberal Education."*

Raphael paints wisdom, Handel sings its, Phidias carves it, Shakespeare writes it, Wren builds it, Columbus sails it, Luther preaches it, Washington arms it, Watt mechanizes it.—*Emerson, "Society and Solitude."*

If some great Power would agree to make me always think what is true and do what is right, on condition of being turned into a sort of clock and wound up every morning before I got out of bed, I should instantly close with the offer.—*Thomas Henry Huxley, "Materialism and Idealism."*

A boy may experiment in catching flies, or a smatterer may experiment in philology; but a philosopher, when he governs himself, in his investigations, by the complex of canons which constitute the experimental philosophy, experimentalizes.—*Fitzedward Hall, "False Philology."*

A BOOK SUPPORT FOR THE CHEMICAL LABORATORY.[1]

By M. G. Mellon,

Purdue University, Lafayette, Ind.

In connection with the development of plans for a proposed new chemical laboratory at Purdue University the author has sought to include, as a part of the equipment, certain novel features which seemed to possess some merit. As a result of a request for suggestions in this direction, an assistant proposed that some scheme be devised for helping the student protect and use more effectively his laboratory book.

This book, consisting of notes or directions describing the work to be undertaken, is provided by each student in the usual undergraduate course in chemistry involving experimental work. It may be either printed or mimeographed, and may be bound or in the form of loose leaves.

On account of the necessity of economizing in the working space allotted to each student, generally little thought is given to providing a place to put the book or sheets when they are being used in the laboratory. As a result, in a laboratory of any size, one finds them in a variety of places and positions. Such a practice leads to several undesirable results, among which may be mentioned the following: a diminished working space, due to the necessity of using part of the available top of the desk, none too large at best, on which to lay the book; the frequent defacing of instructions through contact with the chemicals accidentally reaching them; the occasional loss of time resulting from pages not remaining open at the desired place; the loss of efficiency in having the book in a place or position where the directions are not easily seen; and the damage done many bound books in breaking the binding in the effort to make them lie flat on the working space. Furthermore, having no definite place for the instructions adds to the appearance of disorderliness in the laboratory.

In order to prevent or minimize these undesirable results, there is suggested the use of the book support illustrated in the accompanying figure. For three semesters the author's students in quantitative chemical analysis have made extensive use of this design. Made from No. 6 wire, preferably of some alloy resistant to corrosion, it is used by slipping the two free ends of

[1]Read at the meeting of the Division of Chemical Education, of the American Chemical Society, Columbus, Ohio, May 1, 1929.

the wire into holes bored in the edge of the reagent shelf usually found on the desks in chemical laboratories. By having the holes slightly larger than the wire, and at a distance apart slightly less than the normal distance between the wires, the support will be sufficiently rigid to hold a fairly heavy book; at the same time it may be removed readily and put in the locker when no longer needed. [2]Supports of this design now in use will hold a book which is as much as one inch thick when open.

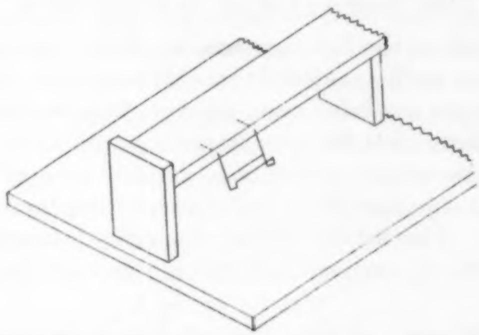


FIGURE 1—BOOK SUPPORT IN POSITION IN REAGENT SHELF.

In addition to the design illustrated, various modifications at once suggest themselves. Of these, the following have been tried, although the one described above is preferred whenever a shelf is available in which holes may be made: one in which the two free ends of the wire are bent to form a screw eye, thus permitting the support to be fastened permanently on the reagent shelf; one having each of the free ends bent into the form of a spring which will slip over the edge of the shelf with sufficient firmness to hold the support properly when in use, and yet will permit its being removed for putting away or placing in a different position; and one which stands by itself anywhere on the top of the desk or on the reagent shelf. The latter modification is accomplished by making the free ends (of the design shown in the illustration) of sufficient length, beyond the bend where they enter the shelf, that, when bent at the same place to form an angle of about 35° with the front upright, they will just reach the table if the support stands in the proper position for holding a book open. This design, which has already been described and placed on the market,[3] is not limited

[2]Supports of this design, made of steel wire and covered with an alloy, are available through the author

[3]The Laboratory, *1*, 72 (1928.)

in its usefulness to chemical laboratories where the desks have reagent shelves, but may be used wherever one wishes to have a book held open at a given page and in a position convenient for reading.

SHALL LABORATORY WORK IN THE PUBLIC SCHOOLS BE CURTAILED—A REPLY TO A CRITICISM.

By W. C. Croxton,

State Teachers College, St. Cloud, Minn.

In an article in the January number of School Science and Mathematics on this subject I ventured to suggest that adequate data are not yet available upon which to base recommendations for substituting lecture-demonstrations for other forms of laboratory procedure involving a greater amount of student activity and for curtailing laboratory space and equipment accordingly. The article contained neither reflections on the sincerity of the experimenters in this field nor the quality of their studies.

In a "Criticism" of the article in the April number of this Journal E. R. Downing twice uses the expression "which the author quotes with approval" while attacking my use of the term "advocates." Although it is possible that the term has for some persons connotations in no wise intended in my article, it was clearly stated in the only instance of its use that their advocacy of the lecture-demonstration method was the result, not the purpose, of their experiments.

The term (demonstration) was inserted in my notes to call attention to the fact that Wiley demonstrated while lecturing. The failure to include in the final typewritten copy the statement that the term demonstration inserted in parentheses is my own is an error and calling attention to errors is in place and appreciated, although the appended implication is untrue. Wiley did not use a pure lecture method for he clearly states that he demonstrated while lecturing. It is, therefore, difficult to appreciate the statement in the criticism to the effect that Wiley used only the text-book, lecture and laboratory methods and the further remark, "It is just such distortion of data that characterizes the advocate and is condemned by the scientist."

In the article I called attention to such studies as those of Meister, Garber, and Watkins as representing viewpoints which should be taken into consideration. Downing in criticizing the

work of Garber and Watkins states, "The data in Mr. Watkins' thesis are more abundant and yet such a variety of teaching devices is included in the project method in both of these studies, that they do violence to one of the fundamental rules of any experiment—that there shall be only one variable present—that one the factor whose influences one is endeavoring to evaluate." On the other hand, in the school Review, Vol. 33, he explains the exceptions to the general results obtained by Cooprider, Cunningham, and Anibal on the basis of variable errors. "It seems likely, therefore, that these exceptions to the general rule that the lecture-demonstration method yields better immediate results are due not to the nature of the experiments in the studies thus far conducted but more probably to variables that have not been taken into consideration, such as room temperature and humidity, light, ventilation, and the fatigue of pupils. The probability is that such variables will offset one another when the data for all the studies are combined and that, in spite of exceptions, the general rule maintains, namely, that the lecture-demonstration method yields better immediate results and only slightly inferior delayed results than does the laboratory method." The importance of limiting the factors in experimentation is unquestioned, but it should be noted that in seeking to accomplish this these workers set up experimental conditions in the form of teaching methods which do not even approximate the usual lecture-demonstration and laboratory methods. This Downing makes perfectly clear. After describing the methods employed in these experiments, he states, "This method of procedure is neither that of the laboratory nor that of the lecture-demonstration as it is ordinarily conducted, for the lecture-demonstration is usually accompanied by exposition on the part of the instructor, and in the laboratory the pupil is assisted and supervised by the instructor, who gives more or less demonstration and exposition. It seems advisable, however, to make the experiment as described in order to determine the results of pure laboratory work in contrast with pure demonstration before attempting combinations of the two."

If conclusions are drawn on the basis of the usual lecture-demonstration and individual laboratory methods, then errors constant in direction are likely introduced through arbitrarily limiting these methods as employed in the experiments. As long as conclusions are limited to the conditions of the experiments, there is no justification for criticising them. It may prove

desirable to measure arbitrary and non-typical procedures, but the sweeping generalizations by Downing in SCHOOL SCIENCE AND MATHEMATICS, Vol. 24, under the caption "Some Radical Departures On the Teaching of Biology" are clearly not justified by these or later experiments. The first paragraph of this article states, "The psychology of science teaching is now sufficiently clarified and the experimental determination of the relative values of method of instruction sufficiently advanced to warrant certain radical changes in our courses of study in biology and the technique of presentation." Later in the article he enumerates some of these changes as follows, "Teach them by the lecture demonstration method. Reduce laboratory work to a minimum. Bar the compound microscope from the High School biology course, and replace it with the demonstration projection microscope. Omit all dissections by students; such a dissection is rarely instructive—it is futile hash. Use prepared dissections when structure is to be studied, remembering that such studies are only to be made when structure is essential to a comprehension of activities. Omit from the notebooks all detailed sketches and replace them with diagramatic sketches." The data are decidedly inadequate for the above generalizations and it is difficult to harmonize their expression with the ideas set forth in his article on "The Elements and Safeguards of Scientific Thinking," in volume 26 of The Scientific Monthly.

There is, moreover, apparent inconsistency in the recommendations contained in his article on "Some Radical Departures On the Teaching of Biology." Regarding the units of subject matter he offers the following suggestions, "Many of these units should be organized in problem or project form to give drill in accurate methods of scientific thinking, for such ability is more important than the acquisition of knowledge." Later in the same article he states, "Teach them by the lecture demonstration method."

Possibly one of the greatest services of the studies which have been made is that of calling attention to the fact that what the experiment proves is relatively little understood by the pupils with either the lecture-demonstration or the traditional laboratory method of instruction. Referring to Cunningham, Downing makes the following statement on this point in his summary of these studies published in volume 33 of the School Review, "His graphs show also what the tabulation of Cooprider's results indicates, namely, that 'what the experiment

proves' is little understood in the case of either method of instruction. In other words, scientific experiments as at present conducted are often to be classed as 'busy work' in high school, interesting perhaps, but not instructive. What the experiments should show—what they are really for—is little realized by the pupils." If this conclusion has any meaning the lecture-demonstration cannot at present be endorsed as the solution of the problem, for subsequent studies have furnished only a very limited amount of additional data on this point. These studies then do not exclude the possibility that the solution lies in more purposeful activities carried to completion by the pupils. It was the sole purpose of my previous article to call attention to the fact that this possibility should be taken into consideration before recommending the substitution of the lecture-demonstration and the curtailment of equipment, space, and time. The comments I have received since the appearance of the article lead me to believe that there are many others who do not feel that the principal path of progress in science teaching, or in education generally, lies along the line of lectures and demonstrations by the teacher; although these may at times be helpful. However, credit is certainly due those persons who by their pioneer experimental studies in the field of method in science teaching have aided in the accumulation of data that may sometime lead to a science of education.

NEW X-RAY MENACE.

X-ray therapy, one of the blessings of modern science, can, in exceptional cases, produce feeblemindedness and deformity in human beings. This possibility has been discovered through investigations by Dr. Douglas P. Murphy of the University of Pennsylvania. He emphasizes, however, that the danger is limited to treatment with X-rays, which does not include the taking of an ordinary X-ray picture.

Mothers shortly before the birth of their children are sometimes treated with X-ray irradiation for malignant growths. If the growing child is subjected to the irradiation from the X-ray machine at the same time that the therapeutic measures are undertaken, it has been determined that there is about one out of three chances that it will be feebleminded. Malformations of the head and dwarfing of the limbs may occur under such conditions. Dr. Murphy has studied over a hundred instances of X-ray treatments under such conditions and he found that serious results had followed in one-third of the cases.

There is no danger in an ordinary X-ray picture if it is taken of the mother before the birth of her child. Neither has Dr. Murphy been able to discover any injurious effects upon subsequent children from X-ray treatments that were given before pregnancy.—*Science News-Letter.*

BACKGROUND AND FOREGROUND OF GENERAL SCIENCE

By Wm. T. Skilling,

State Teachers' College, San Diego, Calif.

No. IV—Light

A sunbeam! Measureably understood by the lowest warm-blooded creature, yet not entirely comprehended by the most advanced modern scientist!

A good point of departure in embarking upon a study of light with a class of young pupils is, "What may happen to a beam of light." Before we have completed the answer we have taught more than should be attempted in a general science class. First, the rate at which it is moving, then the change of rate on entering some substance as air or glass, and the consequent tendency to bend and disperse into colors. Then reflection from smooth surfaces and the scattering or diffusion from irregular ones. Next, if one had older students, would be diffraction into all directions on going through a very small opening, and the polarization or limiting to one plane the vibrations when the beam passes through certain crystals or is reflected at a certain angle.

The matter of velocity and its determination makes an appeal to any mind, and should not be thought too difficult to touch upon. The principle on which rests the accurate determination of the speed of light is that we must either have something corresponding to a stop watch delicate enough to time it over a short course, or have a course long enough so that delicacy of timing is not necessary.

Roemer, of Denmark, in 1675 used the latter of the two. His distance along which he timed the passage of a ray of light was the diameter of the earth's orbit, 186,000,000 miles, and the time was a thousand seconds—easily measured.

Fizeau, much later (in 1849), used a distance of only a little more than ten miles, about five miles to a mirror and five back. His "stop watch" was a rapidly turning toothed wheel. It had to turn sufficiently fast so that a cog should move far enough to occupy the place of a space during the time that a jet of light passing through a space traversed the ten mile course—about 1-18,000 of a second.

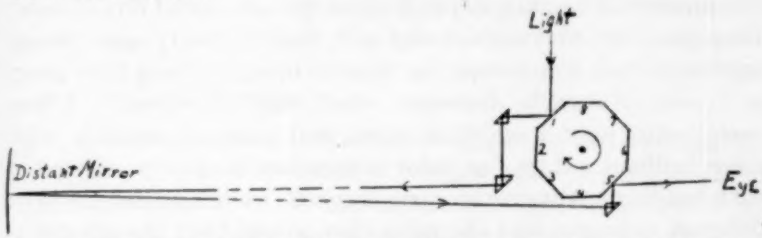
Foucault, a fellow-countryman and contemporary of Fizeau, made use of a rapidly revolving mirror as a timing device. The light to be measured is reflected from the turning mirror to a

stationary reflector some distance away. From this it comes back to the first mirror again, but finding it now set at a different angle is reflected in a different direction from what it would have been if the mirror had remained stationary. The amount that the mirror has turned gives a measure of the time required by the light in going to the distant mirror and returning.

So sensitive is this method that Foucault was able to measure the velocity of light over a distance between two points in the same room. He also passed light through a tube ten feet long filled with distilled water and found that the velocity in water was only about three-fourths as great as in air.

This result had been predicted from a study of refraction.

In one of Professor Michelson's recent determinations of the velocity of light, using Foucault's method, he used an eight sided mirror in a laboratory on Mt. Wilson, and reflected light from it to a mirror at a forest ranger's camp on Mt. San Antonio, 22 miles distant.



AN OCTAGONAL MIRROR USED FOR TIMING THE SPEED OF LIGHT

He rotated the mirror just fast enough (528 times a second) so that it would turn one-eighth of the way around while the light leaving one face was making the round trip of 44 miles.

When the jet of light returned it did not strike the face that would have been waiting for it if the mirror had been stationary but the next adjacent face.

The high speed of rotation caused the mirror in one of the preliminary tests to explode from the strain put upon it by centrifugal force, cutting the experimenter.

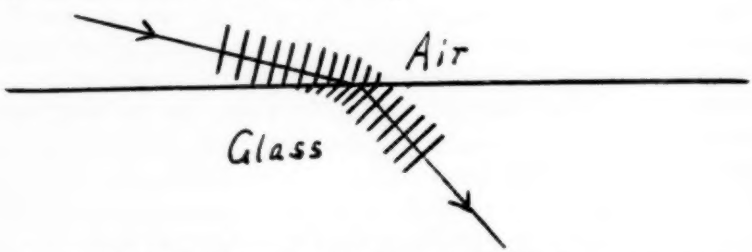
An interesting part of Michelson's determination of the velocity of light was the measurement of the distance from Mt. Wilson to Mt. San Antonio. This measurement, over the roughest imaginable territory was made for him by the U. S. Coast and Geodetic Survey. They of course did it by triangulation. The base line was measured over as level a stretch as could be found through the orange orchards along the foot of the range of mountains.

Such care was used both in measuring the base line and in finding the angles from it to Michelson's two stations that the air line of about 22 miles between the two mirrors is said to be the most accurately known distance ever found by triangulation in any part of the world. The error is thought to be not more than half a centimeter.

After numerous measurements with various mirrors of somewhat different construction Professor Michelson gives 186,285 miles per second as the velocity of light in a vacuum. The actual velocity in the air of the mountains where the measurement was made was about 41 miles per second slower than this.

Fortunately light does not travel so fast on entering a material substance as it does in empty space. Fortunately because it is this that causes light to bend, and makes optical instruments possible.

The simple little refraction diagram showing the wave fronts of a ray of light retarded thus bending the ray is very instructive. The amount of bending depends upon the amount of retardation. Thus glass, in which the velocity is ⅔ that of empty space bends light more than water does, the velocity in water being ¾ as great as in air. Naturally diamond, which cuts the speed to 4/9 of itself bends light more than glass, and makes it sparkle with more brilliant colors, for color separation is closely associated with bending. Always the various colors (wave lengths) are bent different amounts, and the more they are all bent the greater is apt to be the difference in bending.



Showing Why Retardation of Speed of Light Causes Bending

But for bending of the ray magnification, as in the microscope, refracting telescope or eyeglass would be impossible. The camera would not focus light. Neither would the eye. And remember, that bending is due to the slower speed in glass or other substance of which the lens is made as compared with speed in air.

To effectively and interestingly teach the laws of optics as they function in our environment a few lenses of various sizes and focal lengths are necessary. One suitable lens, a chalk box and a piece of ground glass will make a camera. Two lenses and a mailing tube are needed for a telescope. The principles at least of the compound microscope may be demonstrated.

Simplify the confusing array of forms which lenses may take by pointing out that there are essentially but two kinds; those with thick centers, which converge light to a focus thus making an image, and those with thin centers which diverge light, and produce no real focus or image. The thick centered kind makes objects look larger—magnify. The thin centered kind make them look smaller.

Pupils should be given a chance to understand the nature and ways of producing color for color is an ever present part of our environment.

As to its nature they should know that color does not reside in the material but in the light that comes from it. Various things differ in color because of their power to send to the eye light of certain colors.

This power often is due to the ability of the material (or the dye in it) to absorb certain of the spectral colors and reflect to the eye the others. In the case of thin substances like a soap bubble or oil on a wet pavement the light coming to the eye is what is left after the rest of the colors have been destroyed, not by absorption, but by neutralizing each other's effect (interference). Or the neutralizing may in other cases be due to there being very fine lines upon the surface (the grating effect). Then there is the separation of colors by refraction without destroying any of them as in the rainbow. A prism held in the sunlight helps to impress the fundamental thought that color is an attribute of light itself.

NEW ANESTHETIC.

Gas anesthetics have become quite the mode in surgical circles lately. A new possibility in this field was presented by Dr. G. W. H. Lucas of Philadelphia and Dr. V. E. Henderson of Toronto. Their gas is known as cyclopropane. Anesthesia of surgical degree can be caused by a mixture of eleven per cent of this in oxygen. The discoverers claim that it is easy to take, leaves blood pressure and respiration practically normal while it is in action and has no bad after effects.—*Science News-Letter*.

COORDINATES IN THE HISTORY OF MATHEMATICS.

BY RUTH M. TAPPER,

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It is the purpose of this paper to trace the course of the developing concept of coordinates with an especial emphasis upon that part of the history which applies to High School Mathematics. In tracing this development we shall not confine ourselves to the relatively short period in which the modern terminology, *coordinate, abscissa,* and *ordinate,* has been common, but rather the idea of coordinate representation. In 1692 the term *coordinate* was introduced by Leibniz, as was also *abscissa* and *ordinate.* Since these terms did not fall, as a meteor from a clear sky, from the mind of Leibniz, but were the culmination of a slowly unfolding thought traceable to pre-Grecian times,[1] we shall begin with the ancient period.[2]

The embryo concept of coordinates existed in pre-Grecian times. As to the exact beginning historians disagree. It is credited to Egypt, to Apollonius, and to Descartes. Whether or not modern graphical methods are directly traceable to this early idea is doubtful. But the existence of the idea among the Egyptians is beyond doubt. From their idea of laying out towns according to rectangular plans Heron acquired his fundamental principles. The symbol, which designated the district, (hesp) in Egyptian surveying was apparently taken from the rectangular division.[3]

During the Greek period vast strides were made toward establishing a foundational concept of coordinates. In this field Menaechmus, Archimedes, and Apollonius, who, according to some authorities, outlined modern analytic geometry, stand out.[4] The Greeks used the idea of coordinates rather than the notation. The method as a subsidiary means came into use among the Greeks; yet it never became a subject by itself. This period is characterized by no marked effort to reduce the lines of reference to the least number possible. Among the three outstanding needs for a further geometrical advance cartesian geometry is noted.[5]

The terminology of the Greeks foreshadows in no small way that of Leibniz and of our modern usage. The Greek said for

[1]Florian Cajori, *A History of Mathematics*, p. 175 (New York, 1924).
[2]David Eugene Smith, *History of Mathematics*, II, 324 (Boston, 1925).
[3]David Eugene Smith, *op. cit.*, p. 316.
[4]Tropfke, *History of Mathematics*, I, 416.
[5]Florian Cajori, *op. cit.*, p. 42.

ordinate, τεταγμένως, "ordinate wise," which usually referred to the tangent at the extremity of the diameter, as in the *Conic Sections* of Apollonius. What is our *abscissa* to the Greek was "the portion cut off," which is the literal translation of *abscissa* derived from *ab*, off, and *scindo*, cut.[6] The geography and astronomy of this period, in connection with longitude and latitude, contain the first literary references to coordinates. About 140 A. D. Hipparchus of Chios located points by longitude and latitude (by Μῆκος and πλάτος), and also found the location of stars by this system. Similarly almost three centuries later Marinus of Tyre and Ptolemy show the same tendency to map the heavens by longitude and latitude.[7]

So far the location of points has been the predominant motive. Heron laid out a field with respect to one axis with the same results we get today.[8] In this period rectangular axes came into play. It is possible that in the fourth century B. C. Menaechmus used the properties of the parabola and of the hyperbola given by our $y^2=px$ and $xy=c^2$;[9] which relations are involved essentially in cartesian coordinates. Again, late in the next century Archimedes used the property of the parabola expressed by $y^2=px$ and represented the central conic by $\frac{y^2}{x.x^1}=$ a constant.[10] Although these men can not be considered fathers of the coordinate system, the ideas of coordinates in Menaechmus and Archimedes were too far from dead to allow them to be passed without mention.

To Apollonius is sometimes given the credit of founding analytic geometry. The more conservative historians grant that he surely anticipated Descartes' method of representation. When he derives his three conics he seeks a relation between the coordinates of any point on the curve referred to the original diameter and the tangent at the extremity of the diameter as axes. These axes are, in general, oblique.

His proposition 5 (I.15.) reads: "If through C the middle point of the diameter PP′ of an ellipse, a double ordinate DCD′ be drawn to PP′, DCD′ will bisect all chords parallel to PP′, and will therefore be a diameter, the ordinates to which are parallel to PP′." In this case C is the origin, D′CD (or more

[6]David Eugene Smith, *op. cit.*, p. 318.
[7]David Eugene Smith, *op. cit.*, p. 316.
[8]Ibid.
[9]Heath edition, *Apollonius of Perga, Treatise on Conic Sections*, p. CXV seq. (Cambridge, 1896).
[10]Heath, *op. cit.*, p. CXV seq.

properly the tangent to the ellipse at P or P′) and VCV′ are the axes. Although D′CD is called a double ordinate, there is no trace of a conception of positive and negative directions in Apollonius. His relation between the general point on the curve

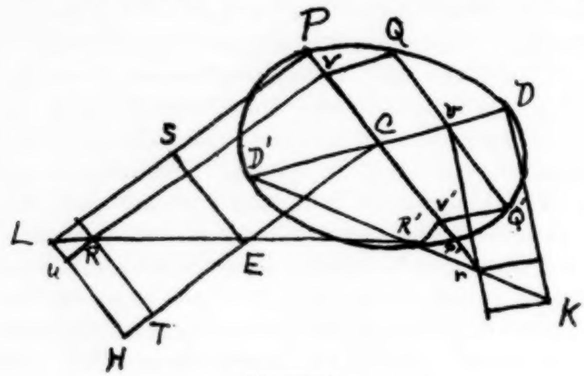

FIGURE 1.

and the tangent at the extremity of the diameter is to him what the second degree equation is to Descartes.[11] Thus Apollonius stepped beyond the stage of locating points on a map to seek relationship, and with a set of axes of reference and with ordinates laid a firm basis, upon which later analytic geometry built.

The glorious period of Greek mathematics, then, showed in Menaechmus, Archimedes, and Hipparchus glimmers of a coordinate concept and in Apollonius a steady gleam.

Despite the general sterility of the Roman period as pertains to mathematical creation, the trail of coordinate history is not lost. Commandinus termed the ordinates *ordinatim applicatae*.[12] Roman towns were laid out on two axes. From Frontinus we learn that the fields were bounded by *decimani* and by *cardines*. The *decimanus* was the line running east and west; the *cardo*, north and south. He says, "The field was divided along rows and along steps." Oblique coordinates also occur in his work. So, the Roman mind was absorbed in the practical rectangular coordinate system.

Just what ideas prevailed in the gap from the Romans to Oresme we can not tell. Yet the coordinate idea was not lost, for in a manuscript, mentioned by Gunther, of the tenth century graphs similar to ours were found; and in this veiled period coordinate paper was used.[13]

[11]Florian Cajori, *op. cit.*, p. 40.
[12]Florian Cajori, *op. cit.*, p. 175.
[13]David Eugene Smith, *op. cit.*, p. 320.

The next person of marked influence in this line was Oresme. About 1360 he was using a plan of representation, based upon the earlier ideas of the practical Egyptian and of the speculating Greek, and yet enlarging upon the restricted aspect of locating points. Smith says he represented the first decided step in the development of the coordinate system. His *longitudines* and *latitudines* correspond to our *abscissas* and *ordinates* respectively. The distance between the ends of two successive *latitudines* was the *gradus*. A series of points determined by the ends of successive *latitudines* composed a *forma*, which was essentially our curve.[14] If the points did not fall in a line parallel to the axis of *longitudines*, the *forma* was spoken of as *difformis per oppositum*.

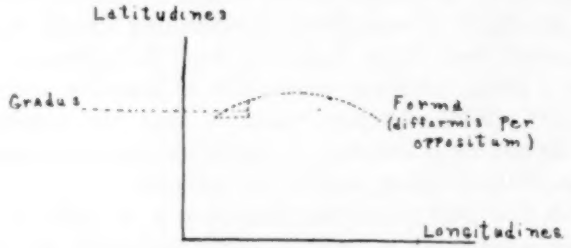

FIGURE 2.

Thus Oresme marked the beginning of a definite system of rectangular coordinates with a systematized terminology, and a partially generalized idea of the *forma*. There is lacking, however, a clear idea of the use of interdependence between the two axes. Nevertheless, the above represents a decided step toward modern coordinate usage.

After Oresme and seven years before Descartes' *La Geometrie* was published, Fermat is known to have had an idea of analytic geometry. He used rectangular axes, marked a general point on the curve I, called the axis containing the feet of the ordinates to the I's *z*, which axis is recognized as our X axis. In a rather bulky symbolism, he stated the equation of a straight line through the origin thus:

D in A aequatur B in E

which partially translated is:

D · A equals B · E

or $ax = by$.[15]

Because he wrote no systematic treatise on the subject and

[14]David Eugene Smith, *op. cit.*, p. 319 seq.
[15]David Eugene Smith, *op. cit.*, p. 322.

failed to advertise his idea before the publication of *La Geometrie*, Fermat is little emphasized in this connection. No doubt his influence is not so overwhelming as to justify greater credit.

So far we have dealt with the purely utilitarian, almost unconscious use of coordinates in the pre-Grecian period, with the conscious technical use in the Roman time, and with the period of growth marked by Oresme. Now we come to the man who effected the culmination of coordinate methods applied to geometry, to the completion of that part of the history of the concept, which directly affects High School Mathematics. We refer to Rene Descartes, the man whose intellect brought order out of chaos, science out of stray methods.

Ball says that the great contribution of Descartes was that he saw the possibility of completely determining a point in a plane by distances,[16] and those from two fixed lines drawn at right angles in a plane, with our convention of negative and positive directions.[17] While Tannery[18] claims that the negative and positive reckoning is not due to Descartes; yet the common use of it is in all probability due to his influence.

He also saw that three coordinates x, y, z could be used to determine completely a point in space, although his attention was given largely to the plane. He says, "I have considered only curves that can be described upon a plane surface, but my remarks can easily be made to apply to all those curves which can be conceived of as generated by the regular movement of the points of a body in three-dimensional space—by dropping perpendiculars from each point of the curve upon two planes intersecting at right angles, the ends of those perpendiculars will describe two other curves (in planes). By the points of these all points of three dimensional curves are determined."[19] Hence, the elements of solid analytic geometry were clear in the mind of Rene Descartes.

Descartes follows Apollonius, in that he relates the points of a conic to the points of a diameter by distances along lines, which make a constant angle with the diameter,[20] which angle is usually 90° in *La Geometrie*. Furthermore he related more than one curve to the same system of coordinates.[21] Finally he reached the majestic conception of determining the curve of an

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[16] W. W. Rouse Ball, *A Short Account of the History of Mathematics*., p. 270 (London, 1919).
[17] W. W. Rouse Ball, *op. cit.*, p. 272.
[18] Florian Cajori, *op. cit.*, p. 175.
[19] Rene Descartes, *La Geometrie*, p. 147 (Chicago, 1924).
[20] Florian Cajori, *op. cit.*, p. 175.
[21] W. W. Rouse Ball, *op. cit.*, p. 273.

equation by a great number of coordinates.[22] In this connection the possibility of graphing an equation of two unknowns was recognized. Then, it was natural to introduce x, y as the abscissa and ordinate. It is not to be implied that Descartes used these terms, but rather the idea. With him the second axis was not a formal convention.

In prefacing a solution he says, "I choose a point A at which to begin the investigation (of curve E C). We are free to choose what we will. No matter what line I should take instead of A B, the curve would always prove to be of the same class."[23] This refers to figure 3, in which A is the origin, A G the axis of abscissas,

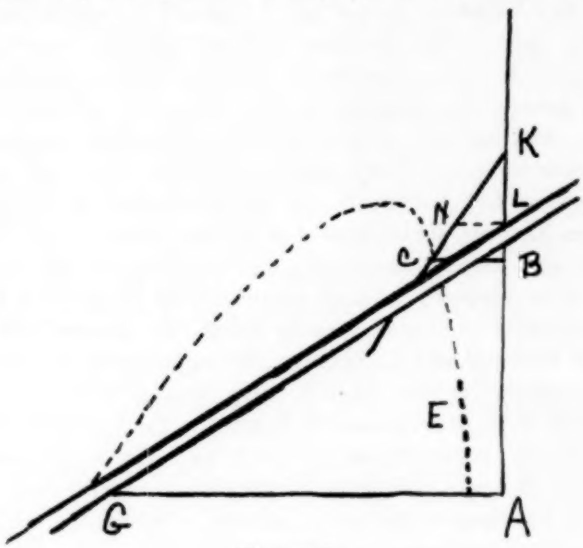

FIGURE 3.

and A K that of ordinates. He takes a point on the curve, C, through which he draws a line C B parallel to A G. Then C B = X; B A $= y$,[24] from which he gets $y^2 = cy - \frac{cx}{b}\, y + ay - ac$.

Advance steps are made by him in the elimination of all but two lines of reference,[25] and in the recognition of the fact that a curve generated by a continuous motion is determined by a number of points taken at random.[26] His ordinates, termed by him lines applied in order to a diameter, resemble the "ordina-

[22] Ibid.
[23] Rene Descartes, *op. cit.*, p. 26.
[24] Rene Descartes, *op. cit.*, p. 52.
[25] Rene Descartes, *op. cit.*, p. 29.
[26] Rene Descartes, *op. cit.*, p. 91.

tion application" of Apollonius.

Descartes emphasizes the idea of coordinates rather than the explicit use of them. Although in the thirty-two drawings in *La Geometrie* the axes are not labeled, an omission which may be due to his general neglect of detail, no one would question Descartes, having used the cartesian coordinate system effectively. While we must seek the methods of analytic geometry in isolated statements, we must acknowledge and respect the greatness of the intellect that gave and the greatness of the gift it gave in the coordinate system named for Rene Descartes.

We have reached the modern stage of coordinates. Since further developments do not affect high school mathematics, we shall but summarize the new features of the concept since Descartes. In the seventeenth century Jakob Bernoulli first used in general the formula for the radius of curvature in rectangular coordinates. Van Schooten and Lahire suggested the use of coordinates in three spaces; and Jean Bernoulli used the idea, but did not publish it. In the eighteenth and nineteenth centuries Leibniz introduced the terms *abscissa, ordinate, coordinate,* and *axes of coordinates,* and laid the foundation for the theory of envelopes[27]. Later contributions include the rules for transformation of coordinates by Euler, the generalized coordinates of Maxwell and La Grange, the application of coordinates to imaginaries by von Staudt, and homogeneous coordinates studied by A. F. Mobius and by Fiedler. Pentaspherical coordinates are the contribution of Darboux. Gauss expressed his curvature (K) as a function of curvelinear coordinates. Kraus and Peters promoted the use of intrinsic coordinates, with which the theory of surfaces is largely concerned; while Jacobi used elliptic coordinates. Finally, the most recent phase recorded in history texts is the use of three systems of straight lines with restricted relation to the axes in the field of nomiography.[28] And to all appearances the end is not yet!

Briefly, we have traced the growth of the coordinate concept as it pertains to high school mathematics. We bow in admiration for the work of many thorough, brilliant students, chief of whom we hold Rene Descartes. Truly the idea of coordinates did not blossom over-night, but through almost twenty-five centuries. And still the bud is unfolding.

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[27] W. W. Rouse Ball, *op. cit.*, p. 363.
[28] Florian Cajori, *op. cit.*, p. 315 seq.

THE KING OF PLANTS.*

By A. G. Zander,

Boys' Technical High School, Milwaukee, Wis.

(The curtain rises on the following scene: A student with a ruler in his hand is examining the cross section of a tree. The specimen should be as large as possible, five feet or more in diameter, with end surface in clean condition. It should be mounted on a small truck if possible. A loud knock is heard at the door.)

STUDENT: Come in. (*Looks up as a rustic old man enters.*) Why, hello, Uncle Ignatius. This is indeed a pleasant surprise.

UNCLE: (*Heartily.*) How are you, my boy, how are you?

S: Very well, thank you, Uncle. I am just in the midst of preparations for what I hope will be an interesting talk which I must give to a Boy Scout organization in a few days.

U: Come, come, don't jest with me. How can you prepare a talk by playing with that enormous log you have there? By the way, that is *some* log.

S: Well you see, Uncle, I am going to talk about a log. So it seems natural, at least so our teacher tells us, to be well posted on the thing you are to talk about even if it be quadratic equations.

U: Ah! I beg pardon. What did you say?

S: It's of little consequence. But let me explain what I am to talk about. Will it bore you?

U: Humph! Depends on what it is. When I came in you had a ruler in your hand as you were at that log. What were you doing?

S: Oh! I was just figuring the age of the tree from which the log was cut.

U: That sounds interesting. Will you tell me about it?

S: Step over here, please. (*Both walk over to the log.*) This old log is in our shops and laboratories. It was a promising sapling when Columbus landed in America.

U: If you expect me to believe that I shall have to hear some pretty convincing evidence.

S: Very well. By examining the surface here (*runs ruler over the surface of the log*) you will notice a series of concentric bands, that is, one within the other. Each of these bands indicates a year's growth in the thickness of the tree - - -

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*This playlet was presented by the Science Department of the Boys' Technical High School, Milwaukee at the June (1929) graduation exercises.

U: (*Interrupting.*) Hold on there, hold on. How do you know but that it takes two of those bands to make that year's growth?

S: By examining a tree from the seedling stage on through many years of growth we know this. This has been done and is now being done right along at our state and federal experiment stations.

U: What interest has the government in these things?

S: It has a great interest. Experience has shown repeatedly that timber and the various influences of the forest are among the most valuable resources of the nation. Therefore the government is very anxious to conserve this resource. To make the use of our forest products more complete, it has established at Madison, Wisconsin, a station known as the Federal Forest-Products Laboratory. The researches carried on there have already for use much which otherwise would not have been fully utilized.

U: (*Pointing to spot on the log.*) Some of these bands are wide, some narrow, some darker than others, some are quite irregular. What do you suppose might be the cause of that?

S: In most temperate climates there are roughly two growing periods of the year as far as the tree is concerned; the Spring or rapid period of growth, and the Summer or slow period of growth. During the Spring there is generally more moisture than in Summer and a wider band of growth results when more moisture is available for the tree. Also there are other things which affect this growth besides moisture, as forest fires, for example. In such cases the leaves of the tree are either burned off or are injured so that they do not do their work properly.

U: How do the leaves affect the growth, eh? That must be explained to me.

S: The leaves supply the tree with material from which the various plant tissues are made, such as the trunk tissues of bark and wood, the blossom, the fruit, and so forth.

U: If leaves do this work how does the material get to all parts of the plant or tree?

S: Let me show you. I believe Joseph here is finishing a diagram showing this. (*Both step over to a table. A large cross section diagram of a stem is placed on an easel. This diagram should be about five feet across and should show in semi-diagrammatic form an exaggeration of the parts actually present in the log. The following things should be clearly shown: the bark layers,*

annual rings, spring and summer wood areas in the annual rings, the heartwood and sapwood shaded in, the pith area.) Do you see this dark band? That is called the bast layer of a stem or tree trunk. This layer is a system of tubes joined together which reach from the leaves to every part of the tree. This colored band shown here represents the live wood. It is also a series of tubes whose job is to bring water and the materials dissolved in this water up to the leaves from the roots. Between these layers is the place where the tree grows in thickness. This place is technically called the cambium, meaning to change, that is this layer changes the plant nutriment into bark tissue on the outside and wood tissue on the inside. You recall I mentioned those tissues to you before.

U: What is all this dark part in this diagram, toward the center?

S: That is the mass of dead wood tubes which have been sort of compressed by the outer layers. These tubes have done their work and are partly filled. This group of tubes then serves as a sort of skeleton for the living part of the tree giving it strength and rigidity.

U: This discussion recalls to my mind an incident which left an unanswered question. Sometime ago a friend and I noticed that a group of trees had among them some which had been injured by having the bark removed. Those that had had only a portion of the bark removed had only a small scar, while those that had the bark torn off all the way around the tree were dead. Could you enlighten me about this?

S: Surely. When bark is removed from the entire girth there is an interruption in the path between the leaves and the roots. The tree will live through the season following the injury because there will be enough material stored in the roots to carry the tree through the summer. The next year that path will be broken and no material can reach the roots from the leaves and so the tree dies.

U: I see. Now what is this particular band here? (*Pointing.*)

S: That is the outer bark and is the protecting layer of the tree. This bark pretty thoroughly protects that precious place, the cambium layer.

U: (*Wanders over to another part of the stage where several large specimens of finished lumber are on exhibit. The most prominent piece is an oak board an inch thick, about six feet long and twelve to*

eighteen inches wide showing the quarter-sawed surface.) My, what a beautiful piece of wood! What is it?

S: That is the familiar quarter-sawed oak. That grain is obtained by what is known as quarter-sawing. That is, the log is cut so that the end cut always passes through the center of the log. Let me show you with this diagram. *(Places on the easel a five foot semi-diagrammatic drawing showing two sketches—one the quartersawed surface with wide pith rays, the other a cross-section of the oak log showing in high relief the radiating pith rays. Publications in which there are suggestive sketches are: Wood and Forest by Noyes, The Manual Arts Press, Peoria, Ill. and The Identification of Furniture Woods, Miscellaneous Circular No. 66, U. S. Department of Agriculture, Washington, D. C.)* You see that wavy band there? That is what is known as the pith ray of a tree. These pith rays extend from the center of the tree to the bark. In some trees these rays are very broad as in the oak. When such a tree is quarter-sawed these rays are exposed resulting in this beautiful grain. Besides the oak the sycamore, beech, maple and cherry show this but not so markedly as does the oak.

U: Do these pith rays serve any particular purpose in the tree?

S: Yes, they act as a crosswise carrying system for the tree making possible the moving of material from the bark toward the center of the tree. They also act as a sort of binder between the bark elements and the dead wood material. This probably gives the oak its great mechanical strength, which we often hear of in proverb, song and story.

U: What a wonderful work of nature a tree is.

S: Not only that, but the tree represents the largest and oldest living thing in existence, the General Sherman, the Sequoia in one of our national parks in California, is this oldest and largest of living things. *(A large water color sketch or a lantern slide of the General Sherman is shown. Ten or twelve sketches or slides of the world's famous trees may be shown with a few words on each. The pictures may be arranged in some geographical sequence and the audience taken on an imaginary trip. Slides may be obtained from the city library extension departments or from other convenient sources at little or no cost.)* The tree is man's companion and friend—a friend we never tire of. It is with the keenest regret that we see a tree being removed. The tree is universally enjoyed by man and beast. The mere sight of a forest in the distance on a summer day stirs in us an uncontrollable desire to

explore its depths and to enjoy its friendly solitude. These simple lines of Joyce Kidmer are a fitting tribute to our friend:

(This poem may be thrown on the screen and delivered as a reading or sung as a solo or by a group of small children.)

"I think that I shall never see
  A poem as lovely as a tree;
A tree whose hungry mouth is pressed
  Against the earth's sweet flowing breast;
A tree that looks at God all day
  And lifts her leafy arms to pray;
A tree that may in summer wear
  A nest of robins in her hair,
Upon whose bosom snow has lain,
  Who intimately lives with rain.
Poems are made by fools like me,
  But only God can make a tree."

A LABORATORY EXPERIMENT ON RANDOM FORCES.

By John W. Hornbeck, Ph. D.,

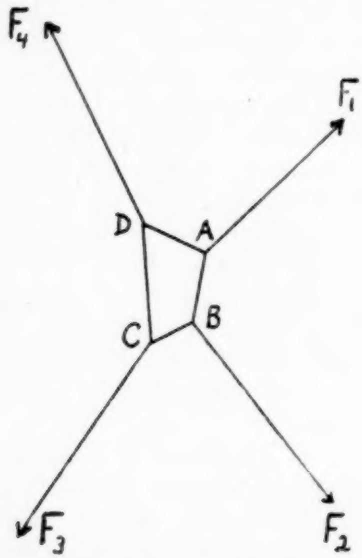
Kalamazoo College, Kalamazoo, Mich.

The experiment on non-concurrent, co-planar forces, as described in the laboratory manuals for college physics, is unsatisfactory. The usual arrangement consists of a rectangular board supported by steel balls upon a flat surface of plate glass or hard wood. The board is drilled at the corneıs of two-inch squares for the insertion of pins to which spring balances are attached by means of strings. The metal pins, or pegs, pass through a sheet of paper covering the upper surface of the board. On this paper the lines of action of the forces are drawn. After reading the spring balances the paper is removed and the student proceeds with the graphical constructions to show that the torques are in equilibrium about any arbitrary point, and that the algebraic sum of the components of all the forces is equal to zero along any line.

The experiment, as described, is disappointing for several reasons. The force board is heavy, especially so if its under surface is covered with plate glass. Because of the rolling friction and lack of perfect smoothness of the glass surfaces, the adjustment for equilibrium lacks sensitiveness. And spring balances are always unreliable. Another difficulty and serious source of error arises in the attempt to locate the lines of action of the

forces. Students find it well-nigh impossible to mark enough points on the paper for the determination of the directions of the forces, without disturbing the position of the force board.

After several attempts to improve this type of apparatus the writer has discarded the foice board. As a substitute a simple quadrilateral of fish cord A B C D, see Figure, is stretched out in a horizontal plane above a large sheet of drawing paper placed and clamped upon the laboratory table. The lines AF_1, BF_2, CF_3, and DF_4, represent braided fish cords that pass over light bakelite pulleys at the edge of the table and support four unequal weights. With this arrangement friction effects can be almost completely eliminated if the four weights are simultaneously set swinging like pendulums and allowed to come to rest. While the vibrations are dying out all four of the points, A, B, C, D, move about with decreasing amplitudes and finally settle into the position of equilibrium. Moreover, since the sheet of drawing paper rests upon the top of the table, rather than a wabbly force board, the student can easily locate ten or a dozen points underneath each string, by using a drawing pencil and a small celluloid right-triangle. In this way the lines of action of the forces are determined with precision.



Through the modifications here described the final results of this experiment are improved remarkably; in fact, about tenfold. The torques and components usually check within two or three

tenths of one per cent. In the opinion of the writer, this is an important matter. All experienced teachers will agree that students are more interested in a laboratory experiment of this kind if it is really quantitative. When a law of physics is put to experimental test, precision is always satisfying and impressive.

It should be added, however, that high accuracy can not be expected in this experiment if the angles are measured with a protractor and the components of the forces computed by the sine and cosine functions. It is much better to lay off the force vectors *on a large scale* and construct their rectangular components with the aid of a celluloid right-triangle; after which, of course, the lengths of the components are measured directly.

There is no objection to a wholly graphical solution such as this, provided the use of trigonometry is required in other experiments. And since this experiment illustrates the general case of co-planar forces in equilibrium, it is not assigned in our laboratory until the student has done experiments with the Force Table and the Simple Crane, both of which involve trigonometry.

CHEMISTRY IN DAILY LIFE.

By Dr. Charles M. A. Stine.

Modern life, which has become more compressed and more scientific also, at every turn, owes most of its possibilities to chemistry. In every case chemistry has been able to release man from purely manual drudgery and free him to lead a life of the mind and spirit rather than a life of bondage to physical labor which was the lot of our ancestors.

The clock we glance at on awakening owes its luminous dial, its crystal, its compensatory movements, even its fabrikoid case-covering to chemistry. As we fling off our pajamas to step into the shower we remember that they are rayon, the first artificial fiber produced by man, and that they are dyed with chemical dyes whose brilliancy lasts as long as the fabric. Our bathrobe waiting for us after the shower is a soft mixture of rayon and wool. The sheets of our bed and the coverlets and blanket all owe either color or softness to chemistry; even the bedsprings themselves were produced by metallurgical chemistry.

The tiled floor and the pyroxylin paneled walls of the bathroom, which are softly colored, are chemical products. The porcelain enameled tub, the various fixtures and the mirror are all produced by some wizardry of the chemist. Not only the razor we shave with but the brush and shaving soap have been improved

by chemistry. The tinted shower bath curtains will not mildew since they have been specially treated. And the beautifully colored toilet set upon the dressing table is a chemical product called pyroxylin, a material light and yet durable and susceptible to many variations.

The suit which we wear is chemically dyed by the new fast dyes which have done so much to improve the wear of fabrics. The buttons on it are molded from a plastic chemically produced. Our necktie is very likely rayon.

The ink and the paper of our daily as we pick it up at the table are both chemical products. The morning glass of water is cleared of germs by the chemist. Our ham or bacon is chemically preserved and shipped and kept in a refrigerated state; again a chemical triumph, since the very ice is chemically produced. Our bread is kept sanitary by a transparent cellophane wrapping which also keeps it moist.

Perhaps the table-cloth which so resembles linen is fairy damask, a washable and durable substitute.

The kitchen where breakfast is prepared is as much a laboratory product as the bathroom. The pipes, the taps, all metal ware, even the aluminum glass and enameled cooking utensils owe their shining perfection to the chemist. The gas range is chromium plated to keep it rustless. The walls are cheerfully colored in a washable lacquer. All the furniture of the house in fact is enameled with this extremely wearable finish.

On leaving the house to get our car, we slip on rubbers because of the rain, perhaps a raincoat too. Both have been chemically treated; the rubber to prevent it deteriorating with the action of air and heat and the raincoat has been chemically impregnated with a material which leaves it rainproof and yet light in weight.

Our car is entirely chemical from the special "gas," which makes it run smoothly, to the waterproof fabrikoid roofing it in, and the durable duco which enamels it in our favorite color scheme. The batteries, the tires, even the button on the horn are the results of chemistry, the latter a chemical resin.

If by chance we are struck by another car, we are protected by the chemist from flying glass, since Duplate safety glass was especially produced to stand blows without shattering.

Arrived at our office the telephone and dictaphone both remind us of the hundreds of chemists constantly experimenting to improve those materials. The very office building itself, put up in

record time, owes its rapid completion to the fact that dynamite has greatly increased the amount and availability of metals and minerals, as compared with hand-labor production in mines.

The fountain pen we sign our letters with is a chemical product, its tube being made of a plastic called pyralin. The shoe paste which the shine-boy is using on our shoes contains a chemical dye and other elements; the box toe of the shoe is Dumold, a chemical product which preserves the shape of the shoe.

In the late afternoon, if we play golf, we may notice that the turf has been improved by the application of a chemical, known as "Semesan," which destroys mold and such like diseases which injure and destroy the fine grass. Our clubs have non-tarnishing alloyed metals in the heads; our golfbag is a lacquer fabric; the ball is made from chemically processed rubber to withstand hard wear.

Going home we see the paint and varnish pots of the decorator who is doing over the house, paints again chemically improved. Our rugs are kept from slipping by what is known as rug anchor, a material placed under the rug.

At dinner the various tropical and western fruits, vegetables, the game and meats are possible to us because of the refrigerated cars used in shipping. Even the matches or lighter we use afterwards on our cigarettes, cigars or pipes, are chemical products. If we pick up a magazine, we remember that the colored photographs are the triumph of a chemist.

If we go to the movies instead of staying home, we are treated to a thousand chemical productions which make the talking and the moving picture possible. And finally when we drop asleep at night, we switch off the electric light, which has been glowing pleasantly on our softly shaded walls and rayon draperies in the manufacture and preparation of all of which chemistry has had a large part.

NEW COURSE OF STUDY IN HEALTH EDUCATION FOR MICHIGAN SCHOOLS.

As the result of a survey made by a committee appointed by the State Council of Physical Education in the fall of 1927, two State committees appointed by the State department of public instruction in 1928 are preparing parallel courses in health education. The first committee working on the course of study has prepared materials in health education to be used in the public schools. The second committee is working out plans and materials for the training of teachers in health education. When the materials for the course of study are ready they will be checked and evaluated by a third committee of experts in health and in education to assure conformity to scientific data and best educational practices.—*Department of Interior.*

PRODUCTION OF STANDING WAVES IN A WIRE CARRYING AN ALTERNATING CURRENT.

By David L. Cook,

Wheaton College, Wheaton, Ill.

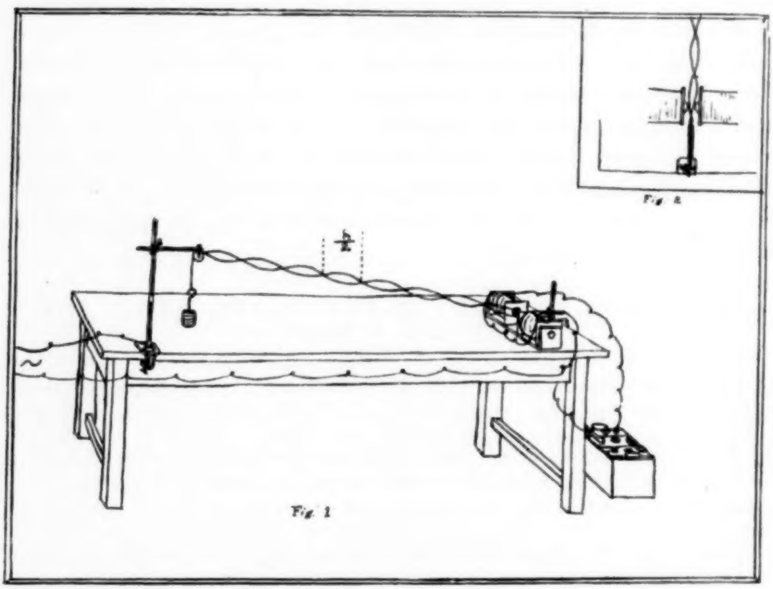
If a No. 22 B. & S. gauge Nichrome wire about eight feet long, carrying sufficient current to heat the wire, be placed in a strong magnetic field the wire will vibrate in loops after the manner of a cord under a light tension attached to an electrically driven tuning fork. The nodes or rest points will become red while the wire is kept cool in the rapidly moving parts of the loops.

This experiment may be used to find the frequency of the alternating current with considerable accuracy. Professor Tyndal has shown that for a light silk cord vibrating in standing waves

$$n = \frac{1}{\lambda}\sqrt{\frac{T}{m}}$$

where n is the frequency of the wave, λ is the length of two loops or a complete wave in the cord, T is the tension on the cord in dynes and m is the mass in grams of one centimeter of the cord.

It was found that if No. 28 copper or brass wire be used the wire is flexible enough to give an error in the frequency as low as about .2%.



If a larger wire be used there is not only an error in reading the tension as the wire passes over the pulley but the speed of the wave is impeded due to the rigidity of the wire, making the wave length too short and giving a rather constant error of too high a frequency.

Greatest accuracy was obtained with as light a tension as would leave the wire fairly taut.

A wire will usually break into loops when the tension does not exactly correspond to the theoretical amount. For a given number of loops the best tension may be found by adding or subtracting weights five grams at a time till the broadest loops are obtained.

By using a No. 28 brass wire 229 centimeters long, with a tension of 140 grams, six loops were formed and n was computed to be 60.1 cycles per second for the current furnished by the Municipal Power Plant at Madison, South Dakota.

Very good results may be obtained by using a strong horseshoe magnet, the electro-magnet shown in the figures being essential for demonstration purposes only.

THE NON-COLLEGIATE DIVISION AT TECHNICAL HIGH SCHOOL.

By Percy E. Rowell,
Technical High School, Oakland, Calif.

About one year ago I wrote to all the school departments in the United States, having an enrollment of ten thousand or more students, in regard to the problem of providing a curriculum for those high-school students who neither care to prepare for college nor to take commercial or industrial courses. I have received so many requests for information concerning the results which have been obtained from the experiment that I have prepared the following bulletin, in which I have tried to incorporate answers to all of the questions which have been asked.

For several years classes have been maintained in the elementary and junior-high schools for those students who, for various reasons, do not fit into the standard classes. When compulsory education raised the limit to eighteen years these students had to be taken care of in special classes, which, for the lack of a better name, were called "Z." It was soon discovered that the work in these "Z" classes consisted of about the same subject matter as in the college-preparatory courses, but given more slowly, and in a manner less rich in detail. Each department of the school,

which had such classes, conducted them independently of the other departments, and there was no co-ordination between them.

The Non-Collegiate Division was started in August, 1928. In January, 1929, courses were being given in English, four classes; mathematics, one class; world history, two classes; United States History, three classes; economic geography, two classes; science, two classes; general language, two classes; Spanish, one class; with twelve teachers. None of these courses were of the diluted form, but were developed into something entirely new. The meetings of the teachers of this division were seminars, in which the problem as a whole was considered, and the teachers were instructed to break away from the traditional, in order to establish effective solutions. The results of all the experiments have been preserved and the gains of this year will serve as foundations for the experiments of next year.

In preparing the courses the teachers were instructed to keep in mind the following objectives: Immediate usefulness, social adaptation, business availability, application to local conditions, preparation for everyday life, to teach current events, whether in mathematics, English, science, geography or history; to make use of a rich content, rather than to dilute it, to give a large variety of topics in order to take care of a quickly changing interest; to make use of the desire for repetition or mechanical processes, to use drawing as a means of expression, to strive for oral expression more than for written work, and finally, which is the most important, to strive for continuous growth and not for a continuous advance in subject matter.

Students may take only one subject in this division, or they may take two, three or four subjects, according to their ability or desires, upon the advice of their counselors. Any student who shows power may be transferred from the Non-Collegiate courses to the college-preparatory courses. The door is always open. We are finding, however, that the courses in this division are proving so attractive that the movement is toward them and not away from them.

If we analyze the kinds of work by which persons earn their living we will realize that omitting the professions, industry and agriculture, they occupy some clerical position. That is, they serve the general public. For this reason their education would first of all develop social characteristics, contain the elements of the many phases of everyday life, and lay the foundation for a later adjustment to changing conditions. College-preparatory

courses, even at their best, do not accomplish this end; they are preparatory only in the sense that they lead toward college. If diluted, as they sometimes are for the so-called "general" courses in the high school, they are even less preparatory for life, if measured either from the social or business viewpoint.

In order that contacts may be made with business, we have speakers from business houses, especially employment managers, address the students of the Non-Collegiate Division concerning the qualities which are deemed desirable in employees.

In general, although we have no hand work, we are planning to develop the laboratory method of teaching in all of the courses. We make use of the visual aids for education, not only by means of projection material, both moving and still, but also material which might be considered as lecture table apparatus.

We are now planning special rooms which are to be equipped for the work, but, since this has not been accomplished, a later bulletin will be issued which will contain a detailed explanation of the new plans and a description of the equipment.

PROBLEM DEPARTMENT.

Conducted by C. N. Mills,
Illinois State Normal University.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name ntroducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

SOLUTIONS OF PROBLEMS.

1067. *Proposed by Norman Anning, University of Michigan.*

The real quadratic equations

$$ax^2+bx+c=0,$$
$$bx^2+cx+a=0,$$

are to have a common root. Show that $a+b+c=0$ is a sufficient condition but not a necessary one.

Solved by Marie M. Johnson, Oberlin College, Oberlin, Ohio.

By Sylvester's Dialytic method of elimination it is found that $a(a^3+b^3+c^3-3abc)=0$ is a necessary and sufficient condition for a common root of the proposed system of equations. Since the factor $a=0$ makes one equation linear, this condition is omitted and we investigate the consequences of

$$a^3+b^3+c^3-3abc=0.$$

Consider this equality as an equation in c, for instance, since the polynomial is symmetric in a, b, and c, and solve. When a and b are any real numbers, we find that c may have any one of the following values:

$$c_1=-(a+b),\ c_2=\tfrac{1}{2}(a+b)-\tfrac{i}{2}\sqrt{3}(a-b),\ c_3=\tfrac{1}{2}(a+b)+\tfrac{i}{2}\sqrt{3}(a-b).$$

If we select $a=b$, then we may take as the third coefficient either $c=-2b$ or $c=b$. In the first case $a+b+c=0$ and in the second case all three

coefficients are equal. However, if we take a not equal to b, then we must have $c=-(a+b)$ since otherwise c would be a complex number and not real. In this case also we have $a+b+c=0$. Consequently, if the two real quadratic equations are distinct, then $a+b+c=0$ is a necessary and sufficient condition for a common root. If the trivial case $a=b=c$ is included, then $a+b+c=0$ is not a necessary condition.

If we consider the system of equations, $ax^2+bx+c=0$ and $cx^2+ax+b=0$, the same conclusions as above are true.

Comment by F. L. Wren, Nashville, Tenn.

The eliminant for the given system of equations is

$$\begin{vmatrix} a & b & c & 0 \\ 0 & a & b & c \\ b & c & a & 0 \\ 0 & b & c & a \end{vmatrix} = (a+b+c)\begin{vmatrix} 1 & b & c & 0 \\ 1 & a & b & c \\ 1 & c & a & 0 \\ 1 & b & c & a \end{vmatrix} = 0.$$

Hence, $a+b+c=0$ is a sufficient condition. It is not a necessary condition, since $a=0$ makes the eliminant vanish.

Comment by the Proposer.

When the given condition is satisfied, the roots of the equations are respectively 1, (c/a), and 1, (a/b). The equations have the root, 1, in common. The condition is sufficient.

To show that the condition is not necessary, put $a=b=c=1$. The equations become identical and either root of one is a root of the other. But $a+b+c=3$, hence not equal to zero.

Note: Methods of advanced algebra supply as the complete necessary condition

$a\ (a+b+c)\ (a^2+b^2+c^2-bc-ca-ab)=0.$

It is, of course, immaterial which of the three factors should vanish.

Also solved by *J. Murray Barbour, Aurora, N. Y.; Smith D. Turner, Goose Creek, Texas; E. de la Garza, Brownsville, Texas; E. A. Hollister, Pontiac, Mich.; J. F. Howard, San Antonio, Texas; Louis R. Chase, Newport, R. I.; and H. D. Grossman, Brooklyn, N. Y.*

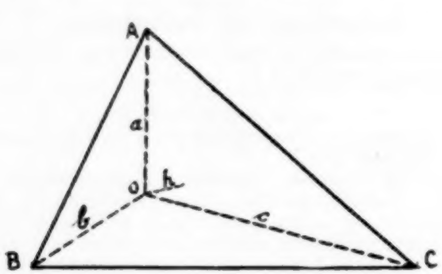
1068. *Proposed by George Sergent, Tampico, Mexico.*

Given O−ABC a tetrahedron with tri-rectangular trihedral angle at O. Designating by h the altitude from O to the base ABC, and by a, b, c the edges OA, OB, OC, prove the relation.

$$1/h^2=1/a^2+1/b^2+1/c^2.$$

Solved by Marquess Wallace, Mexico, Mo.

Consider the face ABC as the base, and h the altitude from O to this base. By problem 1047, the square of the area of the base ABC is equal to the sum of the squares of the areas of the faces AOB, AOC, and BOC. Hence we have two expressions for the volume.



$$\frac{abc}{6}=\frac{h}{6}\sqrt{a^2b^2+a^2c^2+b^2c^2}.$$

Simplifying, and solving for $1/h^2$, we get

$$1/h^2=1/a^2+1/b^2+1/c^2.$$

Also solved by *Louis R. Chase, Newport, R. I.; J. F. Howard, San*

Antonio, Texas; R. T. McGregor, Elk Grove, Calif.; A. J. Patterson, Wheeling, W. Va.; F. L. Wren, Nashville, Tenn.; Smith D. Turner, Goose Creek, Texas; and the *Proposer.*

1069. *Proposed by Daniel Kreth, Wellman, Iowa.*

A boy buys 80 marbles for 80 cents. A blue marble costs 4/3 of a cent; red costs 5/4 cent; white costs 9/25 cent. How many marbles of each color does he buy? Solve by allegation.

I. *Solved by E. de la Garza, Brownsville, Texas.*

	1	2	3	4	5	6	7	8
	4/3	1/3	48		48	24	23	27
1	5/4	1/4		64	64	32	32	28
	9/25	16/25	25	25	50	25	25	25

At the extreme left we write the average price which is 1c. In the first column we write the three different prices and in the second column the differences between those prices and the average price. In the third column we compare the marbles of 4/3 cent cost with the 9/25 cent ones. 1/3 is equal to 25/75 and 16/25 is equal to 48/75; hence, we have to take 48 marbles of 4/3 cent to 25 of 9/25 cent to obtain the 1c. average. In the fourth column we compare the marbles of 5/4 cent with the 9/25 cent ones. The difference 1/4 is equal to 25/100 and 16/25 is equal to 64/100; hence, we have to take 64 marbles of 5/4 cent to 25 of 9/25 and we write that in the fourth column. In the fifth we write the total of the third and fourth. As the grand total is much in excess of 80 and all of the numbers are multiples of 2, we divide each one by 2 and form the sixth column, of which the sum is 81, or one in excess of 80, the desired number. To correct that we have to take off one marble and one cent. We cannot take off any marbles of 9/25 cent, because the L. C. M. of 1/3 and 16/25 or of 1/4 and 16/25 is too large a number to make the correction practicable. The next step is to take off one of either 4/3 or 5/4 cent cost. We will take off one of 4/3 cent forming thus the seventh column. The number of marbles is now correct (80), but the value of them is short 1/3 cent. To correct that we note that changing a marble from 5/4 to 4/3 cent, we gain 1/12 cent. Hence to gain 1/3 or its equal 4/12, we have to change 4 marbles from the 5/4 cent group to the 4/3 one and finally obtain the eighth column with 27 marbles of 4/3 cent, 28 marbles of 5/4 cent and 25 marbles of 9/25 cent.

II. *Solved by Kathleen Lay, Cheney, Wash.*

Algebraic solution. Let x = the number of blue marbles; y = the red marbles; z = white marbles; $4x/3$ = cost of blue marbles; $5y/4$ = cost of red marbles; and $9z/25$ = cost of white marbles. Then we have the following system of equations:

$$x+y+z=80 \qquad (1)$$

$$4x/3+5y/4+9z/25=80. \qquad (2)$$

Substituting the value of x from (2) in (1) and then solving for y in terms of z, we get

$$y=\frac{8000-292z}{25}.$$

Since y is to be integral and positive, the least value of z is 25. Hence $y=28$, and $x=27$.

Also solved by *George Sergent, Tampico, Mexico; A. H. Heiby, Chicago, Ill.; M. G. Schucker, Pittsburgh, Pa.; Louis R. Chase, Newport, R. I.; J. F. Howard, San Antonio, Texas; A. J. Patterson, Wheeling, W. Va.; Smith D. Turner, Goose Creek, Texas;* and the *Proposer.*

1070. *Proposed by R. T. McGregor, Elk Grove, Calif.*

AB the base of a triangle is fixed, and k the sum of the other two sides is given. Prove that the locus of the foot of the perpendicular from B to the bisector of the exterior vertical angle is a circle whose diameter is k.

I. *Solved by Louis R. Chase, Newport, R. I.*

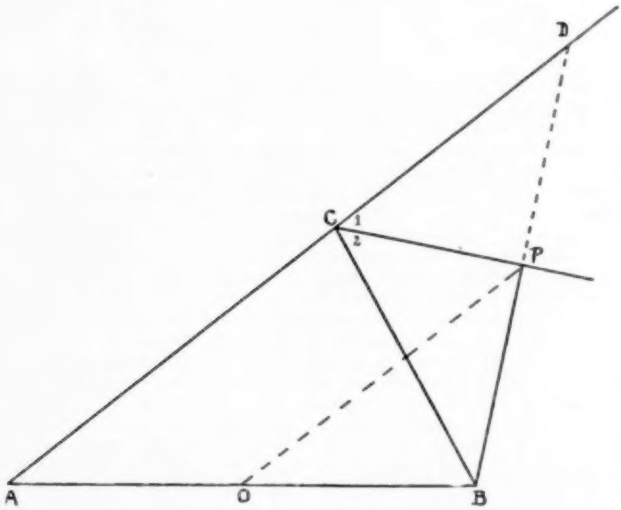
Let O be the mid-point of AB.

First. P being any position of the given point, to prove that OP = ½k.
Produce BP to meet AC produced at D.

∠1 = ∠2, CP = CP, therefore the right triangles are congruent, whence BP = PD, and BC = CD, thus AD = k. Now OP = ½AD, i.e., OP = ½k for O, P are mid-points of AB, BD.

Second. Letting OP be equal to ½k, for any position of P to prove P satisfies the given condition.

Draw line BPD so that PD = BP. Draw AD. Draw PC perpendicuiar to BD, meeting AD at C. Draw BC.



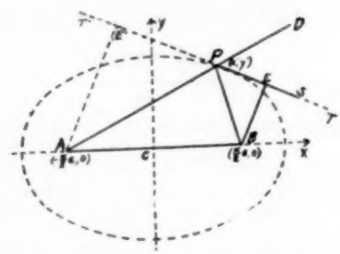
Now AD = 2 OP = k, for O, P are mid-points of AB, BD.

The right triangles are congruent, for the legs are equal, resp.

Therefore BC = CD, thus AC + BC = k. Also ∠1 = ∠2. Therefore any point satisfying the given condition lies on a circle with center O and radius ½k, i.e., diameter k; and any point on the circle satisfies the given condition. Hence the circle is the locus of the point.

II. *Solved by Lester McKee, Hartville, Ohio.*

Given triangle ABP with fixed base AB and AP + BP = k; also the exterior angle DPB bisected by SP, and BE ⊥ at E.



We desire to prove that the locus of the point E is a circle with a diameter equal to k.

From the definition of an ellipse, A and B are foci of an ellipse which is the locus of P. Draw TT′ tangent to the ellipse at P. Then ∠T′PA =

$\angle BPT = \angle DPT'$. Hence TP bisects the exterior angle BPD, and coincides with the bisector SP. Hence T'PS is tangent to the ellipse. Choosing the axes of the ellipse as the coordinate axes, and e less than 1, we represent the following points as follows: $A(-ke/2, 0)$, $B(ke/2, 0)$, $P(x', y')$. Using these coordinates it is not difficult to show that the equation of the locus of the point E is

$$x^2+y^2=(k/2)^2.$$

Also solved by *F. L. Wren, Nashville, Tenn.; J. Murray Barbour, Aurora, N. Y.; George Sergent, Tampico, Mexico; A. J. Patterson, Wheeling, W. Va.; H. D. Grossman, Brooklyn, N. Y.; J. F. Howard, San Antonio, Texas;* and *M. G. Schucker, Pittsburgh, Pa.*

1071. No solutions received. This problem appears again in this issue as 1085. Taken from Loney's Plane Trigonometry, problem 27, page 289.

1072. *Proposed by E. de la Garza, Brownsville, Texas.*

9 is the square root of 81, and $8+1=9$; 45 is the square root of 2025 and $20+25=45$; 55 is the square root of 3025, and $30+25=55$. Find a number of six figures satisfying the same condition.

Solution by H. D. Grossman, Brooklyn, N. Y.

Let x represent the left three digits, and y the right three digits. Then $1000x+y=(x+y)^2$, where x and y are less than 1000. Let $(x+y)=z$. Then

$$z^2=1000x+y=z+999x.$$

Hence, $z(z-1)=999x=(27)\ (37)x$.

Since x and z are less than 1000, $z=1$ or 999. $z^2=000001$ or 998001.

Since z and $(z-1)$ are relatively prime we have

$$z=27m$$
$$z-1=37n$$

whence, $27m=37n+1$. Smallest integral values of m and n are $m=11$; $n=8$. Hence, $z^2=297^2=88209^2=(88+209)^2$

$$z=37m$$
$$z-1=27n$$

whence, $37m=27n+1$. Smallest integral values of m and n are $m=19$, $n=26$. Then $z^2=703^2=494209^2=(494+209)$.

The following *Theorems* are interesting.

I. In the interval 10^{k-1} to 10^k there are 2^r solutions if r is the number of different primes that divide 10^k-1.

II. In any interval 10^{2h} to 10^{2h+1} there are always at least four solutions; in any interval 10^{2h+1} to 10^{2h+2} there are always at least eight solutions (h is greater than 0).

III. There is no upper bound to the number of solutions in the general interval.

IV. The sum of the digits of every solution $\equiv 0$ or 1, modulo 9.

V. If z is a solution in the interval 10^{k-1} to 10^k, 10^k-z is also a solution and the y of the latter solution equals the y of the former.

VI. In any interval 10^{2n-1} to 10^{2n}, $5(10^{2n-1}+10^{n-1})$ are always solutions.

The following table is a list of all the numbers less than 100,000 and 10 of the 32 numbers from 100,000 to 1,000,000 that satisfy the condition. For the purpose of symmetry the number 1 is included in every interval. Opposite each group is the fundamental equation that determines the solutions.

No. N	N^2	$x+y$		Equation
1	01	0+	1	$z(z-1)=9x$
9	81	8+	1	
01	0001	00+	01	$z(z-1)=99x=(9)(11)x$
45	2025	20+	25	
55	3025	30+	25	
99	9801	98+	01	
001	000001	000+	001	$z(z-1)=999x=(27)(37)x$
297	088209	088+	209	
703	494209	494+	209	
999	998001	998+	001	

0001	00000001	0000+	0001	
2223	04941729	0494+	1729	
2728	07441984	0744+	1984	
4950	24502500	2450+	2500	$z(z-1)=9999x=(9)(11)(101)x$
5050	25502500	2550+	2500	
7272	52881984	5288+	1984	
7777	60481729	6048+	1729	
9999	99980001	9998+	0001	
00001	0000000001	00000+	00001	
04879	0023804641	00238+	04641	
17344	0300814336	03008+	14336	
22222	493817284	04938+	17284	$z(z-1)=99999x=(9)(41)(271)x$
77778	6049417284	60494+	17284	
82656	6832014336	68320+	14336	
95121	9048004641	90480+	04641	
99999	9999800001	99998+	00001	
000001	000000000001	000000+	000001	
142857	020408122449	020408+	122449	
181819	033058148761	033058+	148761	
461539	213018248521	213018+	248521	
499500	249500250000	249500+	250000	$z(z-1)=999999x=(7)(11)(13)(27)(37)x$
500500	250500250000	250500+	250000	
538461	289940248521	289940+	248521	
818181	669420148761	669420+	148761	
857143	734694122449	734694+	122449	
999999	999998000001	999998+	000001	

Also solved by *E. A. Hollister, Pontiac, Mich.; Mary E. Bolan, Fayetteville, N. C.; S. Chuang, Ping-yang-fu, Shansi, China; J. F. Howard, San Antonio, Texas; Louis R. Chase, Newport, R. I.; J. Murray Barbour, Aurora, N. Y.;* and the *Proposer.*

PROBLEMS FOR SOLUTION.

1085. *Proposed by the Editor.*

If perpendiculars be drawn to the sides of a regular polygon of n sides from any point on the inscribed circle whose radius is a, prove

$$\frac{2}{n}\sum\left(\frac{p}{a}\right)^2=3, \text{ and } \frac{2}{n}\sum\left(\frac{p}{a}\right)^3=5.$$

Loney's Plane Trigonometry, problem 27, page 289.

1086. *Proposed by the Editor.*

Using a circle construction, find graphically the roots of

$$x^2-ax+b=0.$$

1087. *Proposed by Norman Anning, University of Michigan.*

The numbers a, b, c and d are all different and satisfy the equations: $ac=b^2$, $bc=ad$, $cd=10ab$. Find the numerical value (or values) of (c^2/abd).

1088. *Proposed by J. F. Howard, San Antonio, Texas.*

Given OA and OB two lines from O; P is any point. Through P draw a line forming a triangle with intercepts on OA and OB, such that the perimeter of this triangle shall be equal to a given line.

1089. *Continued solution of 1050.*

In the printed solution of 1050, April, 1929, page 422, there is no proof that all the coefficients shall be integers. Give a proof that all the coefficients shall be integers in the expansion of $\sqrt{1-4x}$.

1090. *Proposed by S. Chuang, Ping-yang-fu, Shansi, China.*

Solve the following system of equations:

$$xyz=x+y+z$$
$$x^2y^2z^2=x^3+y^3+z^3,$$
$$x-y-z=0.$$

AN ANNOTATED BIBLIOGRAPHY OF CONTRIBUTIONS TO SCHOOL SCIENCE AND MATHEMATICS DESCRIBING INGENIOUS AND HOME MADE PHYSICS APPARATUS.

By George W. Haupt,

Washington High School, Ridgefield Park, N. J.

There are extant in educational and scientific periodicals, and with those dealing with the teaching of the various sciences, many articles describing the construction and use of novel, ingenious and homemade pieces of apparatus for demonstration purposes and individual laboratory use. Many of these devices are extremely useful, some because of their simplicity more desirable than the commercial pieces used for similar purposes purchased from supply houses. It is the belief that if all of these contributions could be brought together in some systematic and convenient form it would be valuable in the science classroom. This study is an attempt to start a classification of this sort, believing that its proper use by teacher and pupil will often further effective teaching and with the case of many pupils motivate learning.

What follows is merely a beginning of the collection of this material using the files of School Science and Mathematics as the source. All of the numbers of this magazine from vol. 1, 1901 to vol. 26, 1926 inclusive were examined, selecting those articles describing apparatus appropriate to Physics.

The classification is made under the usual headings of Mechanics, Heat, Light, Sound, etc. and then further classified under these divisions as considered expedient for ease of reference. This is done in much the same manner as a card index system for classroom and laboratory use can be made from this collection.

After the classification under the topic units as described above the information concerning the contributions is recorded throughout this paper in the following order: (1) The title of the article as stated by the author. (2) The contributor's name. (3) The source of the article, including volume, page number and year. (4) A few brief comments giving a clue to the nature and possible uses of the appliance, thus aiding in selection. (5) In many cases a statement of the materials required for construction and manipulation of the device.

Mechanics.

Solids.

AN ACCELERATION APPARATUS, L. E. Akeley. 9: 478-480, 1909. A simple acceleration apparatus made from laboratory material. Can be

used so as to illustrate the motion of projectiles and the relations between force, mass and acceleration. Weights, metal ball, pulley, metal rod.

ACCELERATION APPARATUS. Roy C. Andrews. 17: 334-335, 1917. A device to avoid the difficulties of the falling tuning fork method. Diagram and table of calculations given.

GIBSON'S ACCELERATION APPARATUS. Del Gibson. 12: 11-12, 1912. Works well in practice. Utilizes electromagnet. Small percent of error. Excellent for demonstration.

AN INEXPENSIVE ATWOOD MACHINE. Philo F. Hammond. 12: 498-502, 1912. Has given excellent results. Total cost about $5.00. Complete directions and diagram.

A CHEAPLY DEVISED ATWOOD'S MACHINE. C. L. Vestal. 11: 129-132, 1911. Construction diagram and explanation is given. Materials described in article.

NEW APPARATUS FOR FALLING BODIES. A. A. Upham. 15: 210-212, 1915. Easily made and highly illustrative.

FREE FALL MACHINE OR ACCELERATION APPARATUS FOR MEASURING G; AND THE LAWS OF FALLING BODIES. I. Thornton Osmond. 20: 602-607, 1920. The body falls absolutely free. Simple in construction.

A SIMPLE APPARATUS FOR DETERMINING THE ACCELERATION OF A FREELY FALLING BODY. W. M. Parker. 12: 562-563, 1912. Will give the value of "g" within one per cent. Simple, direct, and accurate.

A FALL APPARATUS FOR ELEMENTARY WORK. A. P. Carman and L. A. Pinkney. 15: 469-473, 1915. An apparatus similar to the Atwood's machine. Complete directions and two construction diagrams.

THE PROJECTION OF "THE GUINEA AND THE FEATHER EXPERIMENT." A. P. Carman. 13: 421-422, 1913. A device for showing the performance and results of this experiment by the use of shadows. For demonstration. Materials specified and described.

A SIMPLE APPARATUS TO ILLUSTRATE THE PATH OF PROJECTILES. John W. Scoville. 12: 194, 1912. Made from the very simplest of apparatus.

AN APPARATUS FOR THE PENDULUM PROBLEM. H. N. Chute. 3: 22-25, 1903. Easily made by teacher or pupil. Accurate. Two figures.

A NEW APPARATUS FOR EXPERIMENTS IN MOMENTS. J. B. Kremer. 14: 404-409, 1914. Constructed by teacher or pupil. Four working diagrams. Materials described in article.

A MOMENTUM BALANCE. Ralph S. Minor. 12: 137-140, 1912. An apparatus for roughly determining the value of the dyne. Can be constructed in laboratory or workshop.

AN IMPULSE APPARATUS FOR THE SECOND LAW OF MOTION. John M. Adams. 14: 520-521, 1914. A device to test the truth of the second law. May be used also to determine the acceleration of gravity. For advanced laboratory work. Diagrams given. Brass plate, sheet brass.

A WALL FORM OF BENDING APPARATUS. C. L. Vestal. 11: 413-415, 1911. A stable piece of apparatus for Hooke's Law and the laws of bending.

A ROOF TRUSS FOR THE LABORATORY. George E. Thompson. 17: 824-825, 1917. May be used for the verification of problems. Two construction drawings given. Materials easily procured.

FOOT APPARATUS. F. C. Van Dyke. 8: 34-36, 1908. For study of the foot regarded as a lever. One diagram. Boards, hinges, spring balance.

EXPERIMENT TO SHOW THE PHYSICS OF A HAMMER DRAWING A NAIL. H. L. F. Morse. 13: 416-418, 1913. Excellent demonstration piece. Photograph, diagram and direction sheet included with the article.

APPARATUS FOR CONCURRING FORCES. Walter D. Bean.

8: 48, 1908. Simple in construction and in operation. Drawing board, 3 spring balances, 3 violin pegs, 4 thumb tacks.

A SIMPLE VOLUMENOMETER. H. Wigley. 3: 451-453, 1904. Especially for beginners. Easily made in the laboratory. Two diagrams and tables of data and computations.

Liquids.

AN INTERESTING EXPERIMENT INVOLVING ARCHIMEDES' PRINCIPLE. W. N. Mumper. 9: 297-298, 1909. A device for demonstration of the phenomena using simple laboratory material. Demonstration hydrometer or loaded rod, tall jar.

AN APPARATUS ESTABLISHING ARCHIMEDES' PRINCIPLE. George George. 3: 21-22, 1903. Made from lamp chimney, two hole cork, glass tubing, rubber tubing, one diagram and table of data and computations.

APPARATUS FOR DEMONSTRATING LAWS OF LIQUID PRESSURE. H. Clyde Krenerick. 6: 681-682, 1906. A simple laboratory demonstration piece for the showing of proportionality of pressure to depth, to density, and independence of shape of containing vessel.

AN APPARATUS FOR ILLUSTRATING LIQUID PRESSURE. A. R. Hagar. 3: 408-409, 1903. A substitute for a set of Pascal's vases. One photograph.

A MODIFIED DEMONSTRATION PRESSURE GAUGE. Edwin H. Hall. 4: 35-37, 1904. Improvements in the Hall pressure gauge. Two construction diagrams.

SPECIFICATIONS FOR A CHEAP AND SERVICEABLE SPECIFIC GRAVITY BALANCE. W. E. Bowers. 1: 477-480, 1901. Directions and working diagrams for construction. Difficulties in construction are stated. Materials are listed and described.

INEXPENSIVE APPARATUS FOR ILLUSTRATING THE "HYDROSTATIC PARADOX." F. R. Gorton. 9: 26, 1909. A recording device made from a lamp chimney.

A DEMONSTRATION OF CAPILLARITY. V. Dvorak. 1: 149-150, 1901. The demonstration can be seen at considerable distance or projected. An explanatory diagram is given.

Gases.

A SIMPLE BAROMETER. C. C. Kiplinger. 14: 568-570, 1914. Homemade or in laboratory. Can be read to tenth of a millimeter. Construction diagrams given. Small wide mouthed bottle, curtain hooks, glass tube, white glass pointer, rubber tubing, ruler, mercury, thermometer, small funnel, filter paper, separatory funnel, concentrated sulphuric acid, mercury sulphate.

STUDENTS' SELF FILLING BAROMETER. F. R. Gorton. 12: 490-491, 1912. Simple and clean. Can be used for demonstration.

A WATER BAROMETER. John C. Packard. 15: 480-481, 1915. A homemade apparatus that extends from the third floor to the basement. Rises and falls by startling amounts. Interesting and valuable.

BOYLE'S LAW APPARATUS. Ralph C. Hartsough. 18: 349-350, 1918. The principle of the U tube. Diagram.

A SIMPLE AND EFFECTIVE BOYLE'S LAW AND CHARLE'S LAW APPARATUS. J. Garrett Kemp. 17: 825-826, 1917. Apparatus must be made by a glass blower. Drawing included. Rubber tubing, bicycle tire valve, bicycle pump, mercury, stopcock, air pump.

BOYLE'S LAW APPARATUS. E. J. Rendtorff. 11: 16-17, 1911. Desirable features are: (1). Elimination of all rubber tubing. (2). No undue exposure of mercury to dust, etc. (3). Scales in immediate contact with tubes. (4). Elimination of all pouring of mercury. Drawing included.

APPARATUS TO ILLUSTRATE BOYLE'S LAW. H. L. Curtis. 5: 187, 1905. Easily constructed and convenient. Uses bulb tube, long glass tube, glass rod, Canada Balsam, mercury, rubber tubing, bicycle valve.

BOYLE'S LAW BY MEANS OF A CAPILLARY TUBE. C. H. Perrine. 5: 48-50, 1905. Capillary tube, mercury, meter stick. Experimental data given. Diagram of operation.

THECARTESIAN DIVER. Philip Fitch. 11: 543-544, 1911. An easily devised piece of apparatus. Two diagrams and explanation. Medicine vial, hydrometer jar.

A SIMPLE SPECIFIC GRAVITY BOTTLE FOR GASES. Arthur W. Gray. 1: 480-482, 1901. Can be used for various gases. Explanation given. Cheap and efficient. Worn out incandescent electric lamp bulb, soft wax.

A DISSECTED SIPHON. J. Edwin Sinclair. 11: 416, 1911. A device for simplying the explanation of the siphon. Materials necessary are easily procurable.

A SPIROMETER AND ITS USE. Grace F. Ellis. 1: 372-374, 1902. Can be made without difficulty. Describes construction and use. Explanatory drawing included. Two ether cans, bell jar, air tube, support, scale.

A CONVENIENT METHOD FOR DETERMINING THE DENSITY OF AIR. A. W. Augur. 1: 28-30, 1901. A device with a low degree of error. Valuable for simplicity and speed. Copper or brass globe with stopcock, balance, bicycle pump, two gallon bottle, 4 hole rubber stopper, graduates, thermometer, manometer tube.

AN APPARATUS FOR ILLUSTRATING THE EQUALITY OF EXPANSION OF DIFFERENT GASES. C. F. Adams. 5: 456-457, 1905. Made from two air thermometers, wooden standard, two small flasks, sulphuric acid, pipette, rubber tubing. Takes little time and easily repeated.

TO REMODEL AN OLD STYLE AIR PUMP. Harrison H. Brown. 8: 322-324, 1908. Requires only simplest machine work. One photograph and two diagrams.

HEAT.

A LINEAR EXPANSION APPARATUS. Clarence M. Hall. 8: 415-416, 1908. For measuring the coefficient of linear expansion of brass. Some material may need to be made to specification. Photograph and table of data.

APPARATUS FOR THE DETERMINATION OF THE COEFFICIENT OF LINEAR EXPANSION OF A METAL TUBE. E. T. Bucknell. 7: 493-495, 1907. Easily fitted up from materials in the laboratory. Yields fair results.

HOME MADE LINEAR EXPANSION APPARATUS. R. O. Austin. 6: 779, 1906. A homemade tubular apparatus. Only expensive piece being the sperometer. Steel rod, steam tube, sperometer.

A SIMPLE EXTENSIMETER. H. N. Chute. 4: 157-158, 1904. Easily and quickly made by pupil or teacher. Two photographs and two figures.

COEFFICIENT OF EXPANSION OF AIR. Harry J. Cloe. 10: 742-743, 1910. Easily made from simple laboratory equipment. Diagram and calculations included.

GAS AND ELECTRIC FURNACES FOR PHYSICS LABORATORY WORK. H. C. Beltz. 13: 577-583, 1913. For construction of furnaces of from 1000 to 4000 degrees Fahrenheit capacity. Materials easily procurable. Thorough discussion. Two photographs. Two sets of diagrams.

A PYROMETER FOR LABORATORY USE. J. B. Kremer. 14: 47-51, 1914. Can be constructed in the laboratory. Two diagrams included. Galvanometer, small resistance box, slide wire Wheatstone Bridge, Daniell cell, two feet of Ia Ia and Superior wire.

A USEFUL TYPE OF AIR THERMOMETER. E. J. Rendtorff. 8: 684-686, 1908. Inexpensive, compact, and universal in its uses. For bench or projection purposes. Construction diagram given.

A SIMPLE GAS METER FOR USE WITH THE JUNKER CALORIMETER AND FOR TESTING SERVICE METERS. C. W.

Waggoner. J. W. Hake. 15: 571-576, 1915. May be converted into an acetylene generator and used as an aspirator.

AN IMPROVED FORM OF STEAM TRAP. Willis E. Tower. 5: 200-201, 1905. Effective. Easy to construct. Latent heat of vaporization of water, etc.

LIGHT.

A SIMPLE WAY OF DETERMINING THE INDEX OF REFRACTION OF LIGHT. George B. Masslick. 5: 266-267, 1905. Uses measuring stick and battery jar. Explanatory diagram.

SIMPLE APPARATUS FOR INDEX OF REFRACTION. F. R. Gorton. 8: 287-288, 1908. Easily assembled from apparatus in the laboratory. Diagram included.

AN INDEX METER. J. Stewart Gibson. 1: 150-152, 1901. Explanations and diagram given. A tumbler, bar of wood, strip of sheet brass, knitting needle.

APPARATUS FOR DETERMINING THE REFRACTION OF WATER. P. G. Agnew. 6: 29, 1906. A modification for determining the index of refraction of water by means of the usual glass jar.

THE USE OF GLASS BLOCKS IN REFRACTION. Henry Garrett. 5: 359-362. A means of treating the experiment more broadly than is usual.

WHAT CAN BE DONE WITH A SUNBEAM. A. E. Dolbear. 1: 141-144, 1901. Some of the uses can be made of sunlight in the laboratory. Cheap and very efficient. Mirror, convex lens, sheeting.

AN EASILY CONSTRUCTED HELIOSTAT. Arthur W. Gray. 3: 162-167, 1903. Easily made with an outlay of three or four dollars. Serviceable and valuable. Construction diagram.

A CAMERA AND OBJECT HOLDER. H. Clyde Krenerick. 8: 656-658, 1908. For copying diagrams and print for use in projection. Photograph of set up. Materials simple.

AN ELEMENTARY OPTICAL BENCH. H. W. Farwell. 16: 488-493, 1916. Simpe and efficient. Built upon a meter stick as usual benches. Three photographs of set up and uses.

SIMPLE DEMONSTRATION OF COLOR MIXTURES. H. Teike. 11: 542-543, 1911. Illustrations of colored lights by means of colored mirrors. Method for making and producing is described. Two diagrams.

A METHOD FOR SUPERPOSING COLORS. F. R. Gorton. 10: 592, 1910. Apparatus described and illustrated.

A METHOD FOR PROJECTING AND BLENDING COLORS. F. R. Gorton. 10: 509-510, 1910. Decidedly effective and inexpensive if projection lantern is at hand. Two complete diagrams given.

A SIMPLE FORM OF SCIOPTICON. C. W. Carman. 1: 33-35, 1901. Specifications and directions for the construction of a cheap and simple projection apparatus. Working diagrams included. Total cost approximately $7.90.

A SIMPLE FORM OF POLARISCOPE. Frederick H. Getman. 7: 484-485, 1907. A simple piece made from a bundle of plates.

SOUND.

A CONVENIENT GASOMETER. N. F. Smith. 12: 376, 1912. Simple, effective and convenient. Will give high gas pressure for sensitive flame.

A USEFUL PENDULUM AND A SIMPLE WIRELESS METHOD FOR THE VELOCITY OF SOUND. Roy W. Kelley. 14: 306-311, 1914. All parts for construction may be found in the ordinary laboratory. Three photographs and three line drawings given.

A NEW FORM OF APPARATUS FOR FINDING THE VELOCITY OF SOUND IN AIR. A. Haven Smith. 6: 590, 1906. A device requiring laboratory set up material. Claimed to be superior in that it does away with the spilling of water and the pupils are enabled to work more efficiently. Glass tubing of various sizes, rubber tubing, fixed pulley, bottle.

A MECHANICAL MODEL FOR THE LECTURE DEMONSTRA-

TION OF BEATS. W. C. Baker. 6: 776, 1906. Simple home made apparatus of two pendulums and a wooden pointer.

A CONVENIENT FORM OF THE NEW SINGING TUBE. Charles T. Knipp. 20: 787-788, 1920. Must be blown from pyrex glass.

EXPERIMENTS WITH VIBRATING STRINGS AND RODS. N. F. Smith. 23: 75-76, 1923. Simplicity and accuracy for work on pitch. Sonometer wire, tuning fork, movable fret.

MAGNETISM.

APPARATUS FOR DIP NEEDLE DEMONSTRATION. Willard R. Pyle. 7: 466-467, 1907. Reduces difficulties of balancing. Diagrams and instructions for making.

ELECTRICITY.

Static.

CHARGE AND DISCHARGE OF CONDENSERS ILLUSTRATED BY MEANS OF AN EASILY CONSTRUCTED MECHANICAL MODEL. Chas. F. Bowen. 12: 486-489, 1912. Very valuable for the purpose specified to date given above. None in this country. Cost trifling.

A SIMPLE INDUCTION DEVICE. The Science Classroom. May, 1925.

Current.

A TUMBLER GALVANOMETER. E. C. Woodruff. 2: 284-286, 1902. Materials of the simplest. Mechanical steadiness. The details of construction are in sight for the pupil. Sensitive. Will stand hard usage.

A HOME MADE GALVANOMETER. Chas. H. Dwight. 21: 770-771, 1921. A rough and ready instrument. Horseshoe magnet, coil of copper wire, No. 30 and No. 40 copper wire, knife switch.

A GALVANOMETER FOR THE LECTURE TABLE. C. F. Adams. 1: 434-435, 1901. A demonstration galvanometer of the d'Arsonval type utilizing a mirror and electric light. Lamp must be enclosed in a box. Can be made by pupils in class or science club.

A SIMPLE REFLECTING GALVANOMETER. J. M. Arthur. 11: 544-545, 1911. Economy of space. No lenses. Easy to adjust. For demonstration. Concave glass mirror, 6 ft. scale, galvanometer, 6 in. bar magnet, incandescent lamp.

A SWITCHBOARD FOR ELECTRICAL TESTING. W. H. Farr. 19: 537-542, 1919. Four figures and construction diagrams.

A BELL SYSTEM ON 220 VOLT MAINS. P. G. Agnew. 6: 744-745, 1906. Apparatus for the care of a bell system on current mains. Bell armature, wooden mount, kerosene, rheostat, sulphuric acid, Frick clock.

A CONVENIENT LAMP BANK. P. C. Hyde. 18: 632-633, 1918. Made from eight lamps and eight switches. Inexpensive and easy to construct.

HOME MADE STORAGE BATTERY FOR PRACTICAL USE. H. R. Brush. 5: 268-272, 1905. One set costs about $15.00 and highly satisfactory. Little deterioration over long period of time. Construction carefully described with necessary diagrams.

THE LEMON CELL. F. A. Kazmarek. The Science Classroom. May, 1925. Voltmeter (0 to 6 V), scrap pieces of sheet zinc and copper, pieces of bell wire, 3 to 6 lemons.

ANOTHER FUSE DEVICE. H. L. Chase. 17: 120-128, 1917. Made from fuse wire, 2 Fahnestock connectors, block of wood. Explanations and diagram given.

A SIMPLE RESISTANCE BOX. Arthur W. Gray. 5: 188-191, 1905. Cheap and accurate. A board, some wire, sheet brass, few nails and some solder.

A CONVENIENT FORM OF LIQUID RHEOSTAT. S. R. Williams. 12: 489-490, 1912. For current of small amperage but fair voltage. Easily constructed.

A HOME MADE HIGH FREQUENCY COIL. N. Henry Black. 4: 151-156, 1904. Inexpensive, easy to build in the workshop, easily

repaired, cost about $25.00. Seven diagrams and one photograph.

DEVICE FOR TESTING ELECTRIC WIRING. Howard M. Nichols. 10: 639, 1910. A device which pierces the insulation and does away with peeling.

INVISIBLE RADIATIONS.

GEISSLER TUBES FROM ELECTRIC LIGHT BULBS. James Bailey. 10: 639-640, 1910. Inexpensive and effective. Made with induction coil, burned out electric lamp, sealing wax.

WIRELESS.

AN INEXPENSIVE WIRELESS SET. H. Clyde Krenerick. 13: 301-302, 1913. Made from apparatus found in the laboratory. Extremely simple and effective.

UNCLASSIFIED.

HOW TO MAKE SLIDES. The Science Classroom. May, 1926.

A SIMPLE WAY TO PROJECT MICROSCOPIC SLIDES. Clyde E. Volkers. The Science Classroom. June, 1927.

HOW TO MAKE A HECTOGRAPH. The Science Classroom. Nov., 1926.

A HOME MADE MIMEOSCOPE. The Science Classroom. Nov., 1926.

A FEW ARTICLES THE TINNER CAN MAKE FOR THE SCIENCE DEPARTMENT. W. E. Bowers. 3: 93-95, 1903. Water bath and stand. Calorimeter. Pneumatic trough. Vasculum.

SOME NEW MODIFICATIONS OF OLD EXPERIMENTS IN PHYSICS. E. S. Bishop. 11: 125-128, 1911. 1. How to obtain the best results from a tuning fork which vibrates sympathetically with another. 2. Demonstration experiment on absorption. 3. Convenient method of projection. 4. Modification of an experiment on air pressure. 5. Modification of the Cartesian Diver—or a Fake Lung Tester. 6. A laboratory method for determining the index of refraction.

A VISIBLE FIRE EXTINGUISHER. Theodore Cohen. 14: 796-797, 1914. Made from milk bottle, small bottle, glass tubing, aluminum ware, sealing wax, sulphuric acid, sodium bicarbonate.

SOME EXPERIMENTS WITH A PIECE OF IRON WIRE. John F. Woodhull. 6: 400-401, 1906. Laboratory experiments or demonstrations with a piece of iron wire. Can be used to illustrate principles in heat, electricity, sound and light.

ACCURATE WEIGHING WITHOUT THE USE OF SMALL WEIGHTS. George W. Todd. 15: 829-830, 1915. An attachment for the beam of a balance. Accurate and quicker than with weights.

DEVICES USEFUL FOR DEMONSTRATION PURPOSES. E. L. Nichols. 1: 77-85, 1901. A paper describing three simple and useful pieces of apparatus. 1. Expansion of air at constant pressure. 2. Maximum density of water. 3. Torsion Balance Electrometer.

AN ALCOHOL BURNER FOR THE LABORATORY. B. S. Garvey. 25: 181, 1925. Cheaply made of brass or galvanized iron. Temperature can be varied. Can be used with air pressure.

BLACKBOARD COMPASS. Perry Ross. 25: 542, 1925. Made in a few minutes and highly satisfactory.

THE POSSIBILITIES OF A "BURNED OUT" ELECTRIC LIGHT BULB IN GENERAL SCIENCE. Ellworth S. Obourn. 25: 516-521, 1925. 1. Oxygen generator and receiver. 2. To show the weight of air. 3. In an air thermometer. 4. To show the principle of the thermometer. 5. An aneroid barometer from a bulb. 6. A fire extinguisher.

AN ATTACHMENT FOR AUTOMATIC DISTILLATION. Roy W. Kelly. 15: 564-565, 1915. An attachment for "Apparatus A" the form of copper boiler used in the laboratory. Only other essential is some form of condenser. Photograph and directions.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

(Please send all correspondence to 10109 Wilbur Avenue, Cleveland, Ohio.)

WHAT'S "IDIOTIC" ANYWAY?

539. Thomas A. Edison's recent examination for the "best" boy in the United States contained this question:

How would one move a boulder without tools when marooned on a desert island?

A young man, eighteen years old, who won second place in the examination, is quoted as saying that he considers the test "idiotic and without point." "Did you ever hear such a senseless question asked in what was supposed to be a mental examination?"

What do we think about it?

Would you like to have the questions (or some of them) republished in this department of SCHOOL SCIENCE AND MATHEMATICS?

HERE'S ANOTHER.

540. *Proposed by G. A. Waldorf, Waukegan, Ill.*

Here is a problem which appeared on this year's high school scholarship physics test at the University of Chicago:

"A bottle half full of water is sealed up at 20°C and put into a kettle of boiling water. What will be then the pressure inside the bottle, neglecting the expansion of water and glass?" (Vapor pressure of water at 20°C. is 17.41 mm. of mercury.)

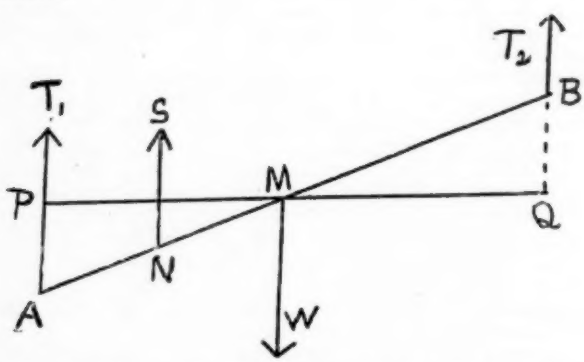
I wonder just what kind of an answer might be expected from an ordinary high school junior or senior in physics?

MR. McGREGOR ANSWERS.

537. *Proposed:* A uniform rod is suspended by two vertical strings attached to its extremities and half of it is immersed in water; if its specific gravity be 2.5, what is the ratio of the tensions of the strings?

Answer by R. T. McGregor, Elk Grove, Calif.

Here is my solution of Problem 537 in the June SCHOOL SCIENCE AND MATHEMATICS:



Let l = length of rod, AB and T_1 and T_2 the tensions of the strings attached at A and B respectively. M is the midpoint of the rod and N the midpoint of AM. PQ is the distance between the lines of action of T_1 and T_2. W denotes the weight of the rod and S denotes the bouyant force of the water action at N. Let c equal the weight of a unit's length of the rod, then $W = lc$, and $S = \dfrac{lc}{2\times 2.5}$, since the sp. gv. of the rod is 2.5. Taking

moments about B, we have $T_1 \cdot PQ + \frac{lc}{2 \times 2.5} \cdot \frac{3}{4} PQ = lc \cdot \frac{PQ}{2}$, and taking moments about A, we have $T_2 \cdot PQ + \frac{lc}{2 \times 2.5} \cdot \frac{1}{4} PQ = lc \cdot \frac{PQ}{2}$. From the first equation $T_1 = \frac{7lc}{20}$ and from the second $T_2 = \frac{9lc}{20}$. Hence the tensions are as 7 to 9.

SMITH TURNER TAKES THE MYSTERY OUT OF HOLLISTER'S MONKEY PROBLEM.

Re Problem 532. *The Famous Monkey-Cocoanut-Sailor Problem* (see April, 1929, SCHOOL SCIENCE AND MATHEMATICS).

The formula $N = 1024X - 3$ discovered by E. A. Hollister may be derived as follows:

Let a = number of nuts each sailor got at last division then $4a+1$ = number fourth sailor left.

$$\frac{4}{3}(4a+1)+1 = \frac{16a+7}{3} = \text{number third sailor left.}$$

$$\frac{4}{3}\left(\frac{16a+7}{3}\right)+1 = \frac{64a+37}{9} = \text{number second sailor left, etc., thus continuing we find}$$

$$N = \frac{1024a+781}{81} = \text{number in original pile}$$

$$\text{or } N = 12a+9+\frac{52a+52}{81}$$

the last term of which must be an integer, as all the others are, so let

$$b = \frac{52a+52}{81}$$

$$\text{giving } a = b - 1 + \frac{29b}{52}$$

As three terms of this are integers, b must be a multiple of 52, so let

$$b = 52X$$

Substituting in the previous equation

$$a = 81X - 1$$

and putting this into the equation for N:

$$N = 1024X - 3$$

where X may be taken arbitrarily.

POSSIBLE TO TUNE BELLS.

A church bell made from the finest bell metal may give forth a harsh, unpleasing sound, due to the fact that it is out of tune with itself. The stroke of a single bell sounds to us like one note, and until very recently even the most expert bell makers have not realized that the sound is really made up of five separate notes. The five notes must be in tune with one another in order that the bell may give forth a harmonious sound. What we then hear is a combination of what is known as the strike note, the nominal, which is an octave above the strike note, the hum, which is an octave below, and the third and fifth.

This recent discovery regarding the harmonics of bells has made possible the new art of bell tuning, a revival of what for two centuries was considered a lost art. The large bells are inverted on a huge turntable and revolve while the metal is pared away from the inside until it is correctly shaped to produce the harmonious tones.—*Science News-Letter.*

DELTA EPSILON, A NEW UNDERGRADUATE HONORARY SCIENTIFIC FRATERNITY FOR COLLEGES.

Delta Epsilon, a national honorary scientific fraternity, is now represented on the campus of Hanover College by the Gamma chapter. Installation services were conducted Friday, May 17, at the Hotel Madison, by Dr. H. T. Davis of the department of mathematics at Indiana university. He was assisted by Dr. Harvey A. Zinszer, professor of physics and mathematics at Hanover college; by W. A. Millis, president of Hanover college and Prof. G. T. Wickwire, of the department of geology at Hanover college.

The purpose of the organization is to stimulate and reward interest in scientific scholarship and research. Membership requirements are: (1) A candidate must have full senior standing; (2) candidates must have a major, 24 hours of accredited and enrolled work, in one department of mathematical or natural science; (3) he must have been in residence for at least one college year; (4) he must have a scholastic average of "B" or 2.0 in the above major science.

During the banquet hour Mrs. V. L. Lochard, violinist, and Miss Elinor Heberhart, pianist, both of North Madison, entertained very graciously with a splendid musical program.

Prof. Wickwire acted as toastmasterter, and introduced Dr. W. A. Millis who, in his most capable manner, gave the address of welcome of the new fraternity to Hanover college.

The installation officer, Dr. Davis, was next in order on the program and after telling a brief history of the fraternity in which he said the mother chapter was located at Colorado college, he added that Hanover has the third chapter, the second having been installed at Denver.

Mr. Davis said in part:

There is one thing to be preeminently learned from history, namely that each age is dominated by some great movement which stirs the activities and imaginations of men. Tell me what men thought and I can tell you the age in which they lived.

There are many forces at work in the present stage of civilization, but I think that it will be denied by few of you that the thing which makes this age different from any other age in the history of mankind is its scientific achievement. The giant machines of industry, the automobile, the airplane, wireless communication, television, the talking motion pictures and countless numbers of lesser devices are transforming the world in which we live.

I do not wish to be understood to say that science is the only influence dominating our lives—far from it—but I do want to say that it is the influence which is most characteristic of our age. It is new and great and powerful, and every day it exerts its influence upon our activities and our thinking.

If this tenet be true, then it is of first importance that all of us who can should have some vision of this great creative force. It is surprising, but true, that most of the technical knowledge which underlies this great force is possessed by a very small army of people. Perhaps ten thousand in America and one hundred thousand in the world would comprise the roll of this technical army. It is a point worthy of profound meditation that the transactions of the American mathematical society, the premier mathematical journal in America, has a subscription list of only 450.

With these brief reflections before us let us turn to the business of the evening. It must be stirring to you as it is to me to know that en-

trance into a scientific fraternity such as this one is symbolic of allegiance to this great new ameliorating force in civilization, that by this act each one of you expresses his desire to become one of this small army of technical experts.

I have spoken briefly of the outer influences of the scientific reformation which started with the work of Kepler and Galileo and Tycho Brahe and Newton and developed so marvelously in the philosophies of Faraday, Clerk Maxwell, Pasteur, Lorentz and Einstein. There is an ideal of scientific research which moved me profoundly when I first heard it and has become since then the fundamental philosophy of my life as a scientist. I want to quote it because I think that it sets up an ideal which removes much of the materialism from modern science. The passage in question was written by Henri Poincare and is found on page 367 in his Foundation of Science:

"The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful. If nature were not beautiful, it would not be worth knowing."

I do not here speak of that beauty which strikes the senses, the beauty of qualities and of appearances; not that I undervalue such beauty, far from it, but it has nothing to do with science; I mean that profounder beauty which comes from the harmonious order of the parts and which a pure intelligence can grasp. This it is which gives iridescent appearances whch flatter our senses, and without this support the beauty of these fugitive dreams would be wholly imperfect, because it would be vague and always fleeting. On the contrary, intellectual beauty is sufficient unto itself, and it is for its sake, more perhaps than for the

good of humanity, that the scientist devotes himself to long and difficult labors."

The response to Dr. Davis' talk was made by Dr. Zinszer. He read some twenty-five letters from candidates to membership in the Hanover chapter in which they expressed their thorough approval of such an organization and a desire to become members.

Dr. Carl Henning, a practicing physician at Hanover, made the response for the alumnus and George N. Bishop, a member of the '29 graduating class at Hanover college was the spokesman for the seniors.

Dr. Millis was then recalled to the floor and presented keys, the fraternity symbol, to the new members. The following is the list of members of Gamma chapter:

Honorary Membership.

Harvey W. Wiley, '67, Washington, D. C.; Stanley M. Coulter, '71, Lafayette, Ind.; Richard E. Shuh, '82, Brooklin, Me.; William A. Millis, President of Hanover college.

Faculty Membership.

Viola Mitchell, mathematics; Ned Guthrie, chemistry; Leonard L. Huber, biology; Grant T. Wickwire, geology; Harvey A. Zinszer, physics.

Active Membership Alumni.

Dr. E. O. Heuse, '00, professor of chemistry, Southern Methodist university; Guy Campbell, '00, geologist, Hanover, Ind.; John D. Gabel, '01, principal Hanover high school; Dr. Carl Henning, '02, physician, Hanover; Dr. Carl P. Sherwin, '09, professor of physiological chemistry, Fordham university; Isabelle Doig, '11, teacher of chemistry, Madison high school; Dr. T. R. Hollcroft, '12, professor of mathematics, Wells college; Arthur Iddings, '13, geologist, Internal Petroleum company, Peru, South America; L. L. Huber, '15, professor of biology, Hanover college; Helen Culbertson, '16, teacher of chemistry, Youngstown high school; Dr. Ira S. Allison, '17, professor of geology, Oregon State Agricultural college; Dewey C. Weir, '23, teacher of mathematics, Hanover high school; Roy D. Black, teacher of physics, Versailles high school; Volney C. Weir, '23, teacher of mathematics, Wabash high school; Charles Bard, teacher of mathematics, Todd school for boys; J. Monroe McKeand, '27, teacher of mathematics, Shelbyville high school; Frank Bard, '28, teacher of mathematics, Crothersville high school; Jesse Harmon, '28, fellow in chemistry, University of Illinois.

Seniors.

Harold Benedict, '29, mathematics; George N Bishop, '29, physics; Cecil Collins, '29, mathematics; Margaret Darragh, '29, mathematics; Elizabeth Dillon, '29, mathematics; Mary E. Holderman, '29, mathematics; Thirza Kurtz, '29, mathematics; Margot Lambertson, '29, mathematics; Louisa Plummer, '29, mathematics; Hope Rankin, '29, mathematics; Helen Vernon, '29, chemistry.

Delta Epsilon was founded at Colorado college in 1920. Beta chapter is located at Denver university. Hanover will be the home of the Gamma chapter.

The organization meeting closed with the election of the following officers:

President, Dr. Harvey A. Zinszer.
Secretary-Treasurer, Prof. Ned Guthrie.
Long Term Senator, Prof. J. D. Wickwire.
Short Term Senator, Prof. L. L. Huber.

CANCER GROWTH CHECKED.

A new clue to the long-sought cure for cancer was presented to the Thirteenth International Physiological Congress by Dr. Boris Sokoloff, of Prague. A compound containing iron and extract of suprarenal gland has arrested the progress of malignant growths in about ten per cent. of all attempts on over a thousand experimental animals, he reported.

When the compound is injected into an animal afflicted with a cancerous growth it causes the malignant cells to liquefy, but has no effect on the healthy body cells. In his experiments the results were obtained very rapidly; in small tumors palpable effects were discernible in from three to five days, while in larger growths the process was a little more slow, requiring about fifteen days.

Thus far, the treatment has been used only on transplanted tumors in mice and rats. What its effects will be on spontaneous tumors has yet to be observed.

An overdose of the treatment carries its own danger, the Prague physiologist stated. Some of his rats got too much, their tumors liquefied too rapidly, and they died. By decreasing the size of the dose and giving repeated injections this unfavorable action was avoided.

The action of the remedy seems to be permanent. Out of 200 rats cured of cancerous tumors over two months ago, only five have suffered a relapse.

The first hints of the possibility of the new treatment were obtained, curiously enough, on organisms at the very bottom of the evolutionary scale. It was found that an iron-suprarenal compound regulated the mutual proportions of the parts of the unicellular animal *Amoeba*, and that an increase in the concentration caused the outer protoplasm to liquefy, killing the organism. The possibility of applying the same treatment to cancer cells, which are essentially normal cells gone crazy about increasing and multiplying, suggested itself to Dr. Sokoloff, resulting in the researches reported.—*Science News-Letter*.

NEW FOSSIL ELEPHANT.

Fossil remains of a pre-historic animal resembling a mastodon, yet somewhat like a modern elephant, are now being obtained near Arkansas City, Kan., by H. T. Martin, curator of paleontology, at the University of Kansas. The specimen is to be mounted and added to the University's museum of fossils.

The specimen is declared to be of especial scientific interest by L. B. Roberts of Kansas City, who accompanied the Roy Chapman Andrews expedition to the Gobi desert, and who has examined the first bones recovered of the Arkansas City find. He is of the opinion that it may prove to be the long-sought "missing link" between the mastodon and the elephant. Whether or not it is a unique specimen, it is declared to be in an unusual state of preservation.

The skeleton was discovered by a telephone lineman, who was excavating for a pole. When he found he had penetrated the skull of an animal, he notified authorities at the University, and Mr. Martin, who was in the western part of the state on his annual summer fossil search, went at once to Arkansas City, and transferred activities there.

The palate of the skull is almost perfect, and two teeth remain—a rather unusual condition. The tusks measure eight feet in length.

Several weeks will be required to excavate the fossil, and the better part of a year will be needed to complete the mounting at the university. —*Science News-Letter*.

ASTRONOMY IN GENERAL SCIENCE.

By Leah B. Allen,
Hood College, Providence, R. I.

Text books in general science that give any place to astronomy lump it all in one chapter; but if the subject were scattered over the entire school year, the pupil would learn more and acquire a lasting interest in the sky without devoting any more time to it than is allotted by the one chapter in the text. The chief difficulty to be overcome is the fear of it felt by the teacher who may know nothing of the sky herself. If she could realize the value both to herself and her pupils of a little effort to acquire first hand acquaintance with the sky, she would accomplish much. Even in big cities by going to a park or some house top it is possible to see enough bright objects for the purpose and in a suburban or rural district it is easy. A set of constellation charts with printed directions is helpful.

At the beginning of the year, find the Big Dipper, North Star, Cassiopeia, and Arcturus. Write in a notebook their positions with reference to certain buildings soon after dark. Record the time and exact place of observation. Look at them again from the same place after 15 minutes or half an hour. Record the changes in their positions. Arcturus will be lower and farther around toward the right. A month later at the same hour of the evening, Arcturus will be much lower, possibly out of sight below the horizon. The Big Dipper and Cassiopeia will be turned differently; the North Star, unchanged.

In the same way some bright star in the east should be noted. It will be seen to rise, but not vertically. The planet Jupiter will be conspicuous in the east November and December evenings. Its motion among the stars can be detected during the succeeding months as well as its daily motion. Similar observations in the spring will show Arcturus visible again, but in the east, rising. So the learner, whether teacher or pupil, sees for himself that the stars rise and set every day like the sun. (Many college graduates do not know that). He also sees the seasonal change in the sky made by the Earth's yearly motion around the Sun. These conditions can be understood only by attention to the stars over a period of several months. A few minutes class room time at intervals through the year given to directions and reports will increase the interest in the chapter on astronomy in the text book, lessen the amount of time needed for it, and make it much more understandable.

BOOKS RECEIVED.

New Plane Geometry by Herbert E. Hawkes, Professor of Mathematics in Columbia University, William A. Luby, Head of the Department of Mathematics in the Junior College of Kansas City and Frank C. Touton, Professor of Education and Director of Educational Research in the University of Southern California. Cloth. Pages vii+428. 13x19 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.32.

Modern Plane Geometry by John C. Stone, Professor of Mathematics, State Teachers College, Montclair, New Jersey and Virgil S. Mallory, Associate Professor of Mathematics, State Teachers College, Montclair, New Jersey. Cloth. Pages xiv+474. 13x19 cm. 1929. Benj. H. Sanborn and Company, Chicago, Ill. Price $1.40.

Algebra for Today by William Betz, Vice-Principal of the East High School and Specialist in Mathematics for the Public Schools of Rochester, New York. Cloth. Pages x+472+46. 12.5x19 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.32.

Problem and Practice Arithmetics, First Book, by David Eugene Smith, Teachers College, Columbia University, Eva May Luse, Iowa State Teachers College and Edward Longworth Morss, Editor of Mathematical Textbooks. Cloth. Pages vii+488. 13x18.5 cm. 1929. Ginn and Company, Boston. Price 80 cents.

The Teaching Unit by Douglas Waples, Professor of Educational Method in the Graduate Library School, University of Chicago and Charles A. Stone, Instructor in Mathematics in the University High School, University of Chicago. Cloth. Pages x+205. 12.5x19 cm. 1929. D. Appleton and Company, 35 West 32nd Street, New York. Price $2.00.

Elementary Statistics by J. Harold Williams, Associate Professor of Education, University of California at Los Angeles. Cloth. Pages xvi+220. 13x19.5 cm. 1929. D. C. Heath and Company, Boston, Mass. Price $2.00.

Introduction to Science by Otis William Caldwell, Professor of Education, and Director of Institute of School Experimentation of Teachers College, Columbia University and Francis Day Curtis, Associate Professor of Secondary Education and of the Teaching of Biology and General Science, University of Michigan, and Head of the Department of General Science and Biology in University High School. Cloth. Pages xvi+658+xxxviii. 12.5x19 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.68.

Outlines of General Zoology by Horatio Hackett Newman, Professor of Zoology in the University of Chicago. Revised Edition. Cloth. Pages xxii+541. 14x21.5 cm. 1929. The Macmillan Company, 60 Fifth Avenue, New York. Price $3.50.

Laboratory Guide and Review Manual for General Zoology by H. H. Newman, Professor of Zoology in the University of Chicago. Cloth. Pages ix+87. 14x21.5 cm. 1929. The Macmillan Company, 60 Fifth Avenue, New York. Price $1.10.

The Prevention of Disease in the Individual by Kenelm Winslow, Attending Physician to Seattle City Hospital and King County Hospital, Washington. Third Edition. Cloth. 431 pages. Illustrated. 13x19.5 cm. 1929. W. B. Saunders Company, Philadelphia. Price $2.75.

Magnetism and Electricity by Morris Meister, New York Training School for Teachers College of the City of New York. Cloth. Pages xiv+210. 19x13 cm. 1929. Charles Scribner's Sons, New York.

A Brief Course in Chemistry by Lyman C. Newell, Professor of Chemistry, Boston University, Boston, Mass. Cloth. Pages vi+412. 12.5x18.5 cm. 1929. D. C. Heath and Company, Boston, Massachusetts. Price $1.48.

Manual of the Vertebrate Animals of the Northwestern United States by David Starr Jordan, Chancellor Emeritus of Leland Stanford Junior University. Thirteenth Edition. Completely revised and enlarged and

with illustrations. Cloth. Pages xxxii+446. 14x20.5 cm. 1929. World Book Company, Yonkers-on-Hudson, New York. Price $4.00.

College Algebra by H. L. Rietz, Professor of Mathematics, University of Iowa and A. R. Crathorne, Associate Professor of Mathematical Statistics, University of Illinois. Third Edition. Cloth. Pages xiii+273. 12.5x19.5 cm. 1929. Henry Holt and Company, One Park Avenue, New York. Price $1.76.

Automorphic Functions by Lester R. Ford, Assistant Professor of Mathematics in the Rice Institute. First Edition. Cloth. Pages xii+333. 14.5x23 cm. 1929. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $4.50.

Exercise Manual in Statistics by Karl John Holzinger, Professor of Education and Blythe Clayton Mitchell, Research Assistant, The University of Chicago. Cloth. Pages v+160. 13.5x20.5 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $2.40.

Poetry and Mathematics by Scott Buchanan. Cloth. 197 pages. 13x19 cm. 1929. The John Day Company, 386 Fourth Avenue, New York. Price $2.50.

The Supervision of Elementary Subjects edited by William H. Burton, Associate Professor of Education in The University of Chicago. Cloth. Pages xix+701. 12.5x19 cm. 1929. D. Appleton and Company, 35 West 32nd Street, New York. Price $2.40.

The Psychology of Learning Applied to Health Education through Biology by Anita Duncan Laton, Ph. D., Teachers College, Columbia University Contributions to Education, No. 344. Cloth. Pages vi+103. 15x23 cm. 1929. Bureau of Publications, Teachers College, Columbia University, New York City. Price $1.50.

Modern Geometry by Roger A. Johnson, Associate Professor of Mathematics, Hunter College of the City of New York, under the Editorship of John Wesley Young, Professor of Mathematics, Dartmouth College. Cloth. Pages xiii+319. 12x19 cm. 1929. Houghton Mifflin Company, 2 Park Street, Boston. Price $3.50.

Smith's College Chemistry by James Kendall, Professor of Chemistry in the University of Edinburgh. Revised Edition. Cloth. Pages xii+759. 14x21 cm. 1929. The Century Company, New York. Price $3.75.

A Laboratory Outline of Smith's College Chemistry by James Kendall, Professor of Chemistry, University of Edinburgh. Revised Edition. Cloth. Pages vi+198. 14x21.5 cm. 1929. The Century Company, New York. Price $1.50.

General Science for Reviews by W. Dean Pulvermacher, Chairman, General Science Department, Jamaica High School, New York City and Charles H. Vosburgh, Principal, Jamaica High School, New York City. Paper. 143 pages. 11.5x19 cm. 1929. Globe Book Company, New York. Price 50 cents.

The Alpha Individual Number Primer by The Supervisory Staff of the Summit Experimental School, Cincinnati, Ohio. Cloth. 31 pages. 17.5x23.5 cm. 1929. Ginn and Company, Boston. Price 40 cents.

The Alpha Individual Arithmetics by The Supervisory Staff of the Summit Experimental School, Cincinnati, Ohio, and illustrated by Kayren Draper. Paper. Book One, Part I has 66 pages and Book One, Part II has 98 pages. 17.5x23 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price Part I 32 cents, and Part II 36 cents.

Science for the Home Manager by George D. Beal, Ph. D., Assistant Director Mellon Institute and Others, Radio Publication No. 48. Paper. 138 pages. 15x22 cm. 1929. Mellon Institute of Industrial Research, University of Pittsburgh. Price 75 cents.

The High-School Science Library for 1928-1929 by Hanor A. Webb, Georgebody College for Teachers, Nashville, Tennessee. Paper. 16 pages. 17.5x24.5 cm. 1929. Price 10 cents.

Proceedings First Colloquium on Personality Investigation held under the auspices of the American Psychiatric Association, Committee on Relations with the Social Sciences. Paper. 102 pages. 14.5x23 cm.

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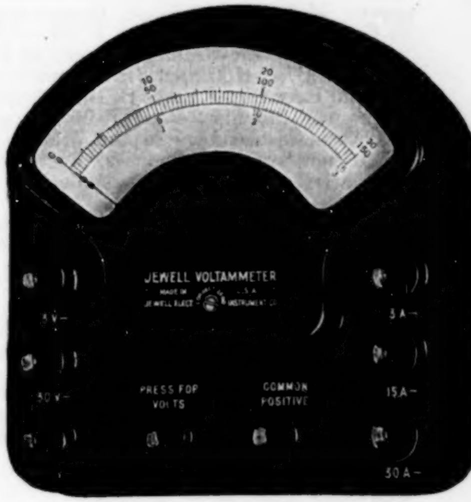

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1928. The Lord Baltimore Press, Baltimore, Maryland. Price 60 cents.

Self-Help for College Students by Walter J. Greenleaf, Associate Specialist in Higher Education. United States Department of the Interior, Bureau of Education Bulletin. 1929. No. 2. Paper. 136 pages. 14.5x23 cm. U. S. Government Printing Office, Washington, D. C. Price 25 cents.

The Rural One-Teacher Schools of Illinois. Circular No. 234. Prepared by U. J. Hoffman, State Supervisor of Rural Schools and Authorized and Issued by Francis G. Blair, Superintendent of Public Instruction, Springfield, Illinois. Paper. 96 pages. 15x23 cm. 1929.

Arithmetic Teachers in the Making by E. H. Taylor, Head of the Department of Mathematics, Eastern Illinois State Teachers College at Charleston, Ill. College Bulletin No. 101. Paper. 16 pages. 15x 22 cm. 1929.

The Milwaukee High School Reading List. Paper. 101 pages. 14.5x22 cm. 1929. The Board of School Directors, Milwaukee, Wisconsin.

Columbia Research Bureau Algebra Test by Joseph B. Orleans, J. S. Orleans and Ben D. Wood. Test 1 Form A and Form B, 8 pages each. World Book Company, Yonkers-on-Hudson, New York. Price of each form per package of 25 examination booklets with Manual of Directions, Key and Class Record, $1.20 net.

Columbia Research Bureau Chemistry Test by Eric R. Jette, Samuel R. Powers and Ben D. Wood. Form A and Form B, 15 pages each. World Book Company, Yonkers-on-Hudson, New York.

BOOK REVIEWS.

Beginning Chemistry, by Gustav L. Fletcher, Chairman, Department of Physical Science, James Monroe High School, New York, Herbert O. Smith, Chairman, Department of Physical Science, Newtown High School, New York, and Benjamin Harrow, Assistant Professor of Chemistry, College of the City of New York. First edition. 1929. Pages viii+476. Illustrated. Cloth. 2x14.5x20.5 cm. American Book Co.

The authors of this new high school text admit in their preface that "of the making of many books there is no end" and that there can be no justification for adding another to the long list of elementary chemistries unless some "sound reasons can be advanced for such an addition." They then proceed to justify the appearance of their new book and in the opinion of the reviewer, with some degree of success. Their thesis is to the effect that "the approach to the subject should be more gradual than is usually the case." With this we quite agree. Even college freshmen are beset with the difficulties of the beginning course in chemistry, with its many new words and ideas, so high school pupils really need to have the "wind tempered to the shorn lamb" and this the authors proceed to do in their first six chapters, in which they make a rather successful effort to present "a very gradual transition from what the pupils already know to what they are expected to master."

The order of events is most natural—a study of the air precedes that of oxygen and nitrogen, and water is studied before hydrogen. Next a study of matter from the modern viewpoint is undertaken so that this viewpoint may be used thereafter as a tool. The chapters on Colloidal Chemistry, Chemistry in Agriculture, Foods and Organic Chemistry are most up to date. The presentation of subatomic structure theory and the basis for it in facts is excellently done. The industrial applications show thorough acquaintance with recent advances in that field. Best of all not too much ground is attempted. The content covers all of the suggested material of the "Standard Minimum Outline" of the Committee on Chemical Education of the American Chemical Society and of the required work of the College Entrance Board. There is much of originality shown by the authors in their treatment and high school chemistry teachers should see the book and judge for themselves if the authors have justified the putting out of another elementary chemistry text.

F. B. W.

A Synthesis and Evaluation of Subject-Matter Topics in General Science, by Francis D. Curtis, Associate Professor of Secondary Education and of the Teaching of General and Biological Science, University of Michigan. Cloth. 83 pages. 15x23 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.00.

The investigation reported in this book is one of the outstanding studies made in the selection of subject matter for general science, or any other science. The successive steps in the technique are:

I. The selection of contributing sources of data.
II. The tabulation of the data from all the contributing sources preparatory to their statistical treatment.
III. The determination of the relative importance or ranks of the topics within each contributing source.
IV. The determination of the weight of each contributing source of data, relative to the respective weights of all the other sources.
V. The determination of the relative values of all the topics within each contributing source.
VI. The determination of the aggregate value of each topic by combining the respective relative values of that topic from all the sources.
VII. The reduction of the aggregate values to percentages of the maximum possible aggregate value, for the sake of more nearly comparison.

These steps give some indication of the enormous task completed by Mr. Curtis. Its value will extend far beyond the field of general science. Science teaching has needed such a painstaking, scientific study of subject matter for a long time. Let us hope many more will follow. This investigation leads the way. Every teacher of science should read this investigation. I. C. D.

Elementary Lessons on Insects, by James G. Needham, Ph. D., Litt. D., Professor of Entomology and Limnology, Cornell Universtiy. First edition. Pages viii+206. 15x21 cm. Cloth. 1928. Charles C. Thomas, Publisher, Springfield, Ill. Price $2.00.

The high school teacher of biology or zoology has long felt the need for just such a book as this master teacher has written. The material presented has been carefully selected and arranged in a most attractive manner. It contains lessons in the structure, development and habits of insects. The principal orders of insects are included, and there are parts of the book dealing with collecting, preserving and rearing insects and with insect control. There is a unique division of the Lessons into a work and laboratory program. The emphasis is placed upon the study of living insects. This book will be valuable as a reference book, and as a thought stimulating guide book to the beginning student of entomology. J. W. H.

Public Health and Hygiene, A Students' Manual, by Charles Frederick Bolduan, M. D., Director, Bureau of Health Education, Department of Health, City of New York. 12mo of 312 pages, with 122 illustrations. Philadelphia and London. W. B. Saunders Company. 1929. Cloth. Price $1.75 net.

The subject matter of the book falls under five distinct heads: Introductory Considerations, including historical development of sanitation, transmission of communicable diseases, disinfection, etc.; Important Communicable Diseases; Other Important Preventable Diseases and Conditions; Community Hygiene; and Prevalence of Disease Generally.

While the book is scientific in its treatment of the subjects of health and hygiene, yet it is written in such a way that it can be read by the average person with only a slight biological background. It is thoroughly practical as it gives just the information that one should have in order to protect the individual and the community against disease.

The book in the hands of the student would provide excellent material to supplement that of a lecture and discussion course in hygiene and sanitation in the junior college. Jerome Isenbarger.

Fundamentals of Physics by A. L. Fitch, University of Maine. Cloth. Pages xvi+336. 14x22 cm. 1929. Thomas Y. Crowell Company, 393 Fourth Avenue, New York. Price $2.50.

This textbook of general physics for college students differs in many respects from all other books in this field that have appeared recently. The first contrast is in size. It is the smallest textbook of college physics that has come to our notice, and contains less than half as many pages as many of the other new physics texts. Much of this decrease in size is accomplished by the elimination of illustrative and descriptive material introduced by other authors to assist in clarifying the meaning of physical concepts, to stimulate interest in the subject, and to show its applications to modern life. But this is not the only means the author has used in his reducing process. Entire chapters common to most books have been completely ignored. Examples are the usual discussion of moisture in the atmosphere and the physical basis of music. The vocabulary has been greatly reduced. The reviewer does not recall any instance of the use in this text of the following terms: alpha particle, proton, audion, colloid, diopter, dynamo, impulse, hysteresis, dew point, eddy current, critical temperature, Avogadro's law, Balmer series, Joly balance, Pascal's law, diesel engine, Brownian movements, Chladni's figures. This list could be greatly extended by comparison with other texts. Many noted physicists whom other texts would not dare to neglect, have been completely ignored or merely mentioned; viz., Madame Curie, Galileo, Franklin, Einstein, Cavendish, Joule and others.

It is quite evident that the author regards the mass of detail common to texts as tending toward confusion, and believes that simplification and clarity can best be accomplished by elimination of all but the most fundamental laws and theories. In this respect the book is unique and should be a very valuable guide to teachers who find difficulty in covering the ground in the allotted time. To some it will no doubt be very illuminating to learn how much can really be omitted and still have left the fundamentals of physics. The language is clear and concise but, because students must be taught to read the language of physics, the reviewer believes the instructor using this book will find it necessary to supplement it very much by lectures, illustrative problems, etc. G. W. W.

The Commonwealth Teacher-Training Study directed by W. W. Charters, Professor of Education, The University of Chicago and Douglas Waples, Professor of Educational Method, Graduate Library School, The University of Chicago and Introduction by Samuel P. Capen, Chancellor, The University of Buffalo. Cloth. Pages xx+666. 15x23 cm. 1929. The University of Chicago Press, Chicago, Illinois. Price $4.00.

This book is the report of the Committee on Administrative Units, a sub-committee of the Committee on Educational Research. The Commonwealth Fund provided $42,000 for this investigation. The study covered a period of three years and is one of the most extensive educational investigations ever made. The success of the committee is largely due to its ability to enlist the cooperation of a veritable army of assistants in all departments of the teaching profession. The study was prompted by a realization of a number of serious faults in present teacher-training curricula and it is certainly safe to predict that it will be very influential in bringing about a reorganization of the work of the teacher-training institutions.

The first problem of the Committee was to determine the traits which teachers in the various types of schools should have. The study of this question produced a list of twenty-five groups of essential traits. The second problem was to determine the types of activities required of teachers. From teachers a very extensive list of activities was obtained from which a master-list was arranged and checked by teachers and others, each activity being rated on four bases: frequency of performance, difficulty of learning, importance, and desirability of preservice training. In chapters IV and V the authors show how the findings may be used in the revision of existing courses and in the organization of new courses in

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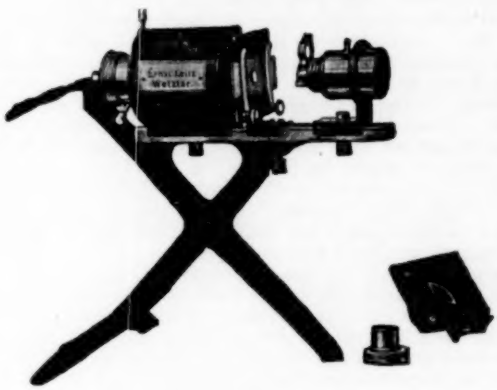

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teacher-training schools. A proper use of these data should rapidly correct much of the duplication in existing courses and put these professional schools on a more scientific basis. G. W. W.

English and Science by Philip B. McDonald, Associate Professor of English, College of Engineering, New York University. Cloth. Pages vii+192. 13.5x21 cm. 1929. D. Van Nostrand Company, Inc., New York. Price $2.00.

Teachers of science will note with pleasure the appearance of this book. It is a step in the right direction. Pupils may come to the science class well trained in reading and interpreting poetry, essays, short stories and other forms of what they have been taught to call literature. They have attempted composition in many of these types and may have won prizes or had their productions published in the school or local papers. But with all of this success the language of science has remained a foreign tongue. They have, in the main had no specific training in the use of scientific language. Many students especially interested in science and technical studies have looked upon the required English courses as so much bunk to be gotten over as quickly and as painlessly as possible. Much of this attitude might be changed if provision were made in the classes in English composition for the study of scientific reports, history of science, descriptions of machinery, and other types of expression necessary in scientific literature. Professor McDonald's book furnishes material and suggestions for a course in English for engineering students. It recognizes the necessity for making correct language the basis of all writing but all illustrations are taken from good scientific writings and the usual chapters on style, punctuation, choice or words, etc., are based on extracts from scientific reports and technical papers. Science teachers in both high school and college should see that this book becomes well-known by their colleagues in the English department. G. W. W.

Elementary Differential Equations, by Thornton C. Fry, Ph. D., Member of the Technical Staff, Bell Telephone Laboratories, Inc. Pages 17x23.5 cm. 1929. Van Nostrand, 8 Warren Street, New York. Price $2.50.

This is a text written by a mathematician who has had much experience, not only as in instructor in the university, but, also, as a member of the Technical Staff of the Bell System for more than ten years. Dr. Fry has, therefore, developed a background which is ideal for writing a text in Differential Equations with a practical turn.

In this text we find the theory developed not only logically but psychologically thus making it easy and pleasant to read. In connection with the theory we find numerous practice problems. In addition to these there are sets of problems, taken from various fields of industry, which give the student an opportunity to apply his theoretical knowledge to concrete situations.

The book may not only be used as a college text, but it should also be read by teachers of elementary mathematics to obtain illustrations of the uses of mathematics as applied to industrial problems.

J. M. Kinney.

The Nature and Meaning of Teaching by Ralph F. Strebel, Assistant Professor of Education, Teachers College, Syracuse University, and Grover C. Morehart, Associate Professor of Education, Teachers College, Syracuse University. First edition. Cloth. Pages xix+273. 13.5x 20.5 cm. 1929. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $2.50.

A class in general methods is frequently composed of students with a great difference in educational background and experience. The authors of this textbook aim to present definite reasons for teaching procedures and to point out specifically how to reach the desired results. In order to accomplish their aims with students of varying degrees of preparation they devote the first half of the book to a study of the educational principles underlying methods of teaching. This first section includes a brief review of the development of a modern philosophy of education, a study of essential social objectives in which the Seven Cardinal Principles

of the Commission of the Reorganization of Secondary Education are accepted as the guide, chapters on the learning processes, the purposes of subject matter, environmental factors, individual differences, and social control. Part II covers the usual subject matter of methods courses.

The authors are acknowledged disciples of Thorndike and have followed his "Laws of Learning" very closely in their interpretation of teaching procedures. The book has many features which make it a very usable textbook: the table of contents is a rather detailed outline; each chapter is followed by a list of problems and exercises, a reference list and a graphical summary; the language is clear and definite; interest is maintained thruout by elimination of needless detail and by keeping the discussions practical. G. W. W.

Introduction to Science by Otis W. Caldwell, Professor of Education, Teachers College, Columbia University and Francis D. Curtis, Associate Professor of Secondary Education and of the Teaching of Biology and General Science, University of Michigan. Cloth. Pages xvi+658+xxxviii. 12.5x19 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.68.

The content of this textbook in general science is based on investigations made of subject matter as reported in "A Synthesis and Evaluation of Subject-Matter Topics in General Science." The book is written in simple attractive language. It is unusually well organized. The development of the subject matter in progressive steps is excellent. Provision is made for differentiated assignments. The book is unusually well illustrated with good teaching material. Each chapter contains tests and guides for further study and review, also scientific puzzles and games. Each new word is defined.

This book furnishes enough material for a full year's work. The results of studies made in the teaching of science are actually used in its preparation. Probably no other textbook in Junior or Senior High School Science incorporates so many modern scientific techniques in selection of subject matter and in methods of teaching. Generous use is made of teaching helps when possible. Topics for special reports occur frequently. Sets of thought questions are given to assist pupils in doing scientific thinking. The glossary is very complete. Lists of reference books are also given. None of the features of an excellent textbook are missing. Teachers, by all means, should investigate this book before they select a textbook. I. C. D.

POISON IN SILVER POLISH.

The shiny, freshly polished spoon or fork may not be the best one to pick out in a cafeteria or hotel dining room, it now appears. A number of cases of acute cyanide poisoning have been traced to polish used on table silver and other metal kitchen or eating utensils in various hotels in New York, the State Department of Health has just reported. No deaths have been reported so far, but a number of persons have been made ill.

When several cases of illness, apparently food poisoning, were reported occurring in persons who had dined at an upstate hotel, health officers began investigations, following every clue that might lead to discovery of the guilty substance that had caused the illness, whether food or germ. They found that the hotel's silver had just been polished. Chemical analysis of the silver polish used showed that about one-fifth of it was composed of poisonous sodium cyanide. Further investigations disclosed that other hotels and restaurants in the state and in New York City were using this or another cyanide-containing polish for their silver.

One woman, whose work entails considerable traveling, reported having suffered twelve different attacks during a year while stopping at hotels in various cities. Some hotels have already reported that attacks of similar illness among their guests have ceased to occur since this type of silver polish has been discarded.—*Science News-Letter.*

THE CONSTANTS OF NATURE AND THE NUMBERS 2, 3 AND 5.

Mr. F. W. Ball, 5559 Blackwelder St., Los Angeles, points out an interesting number coincidence. He says:

"All the fundamental constants of nature may be expressed in integral powers of the numbers 2, 3 and 5. . . . In the constants connected with the electron e, h, c and a, 3 appears in the numerator, but in those connected with the proton, K and G, in the denominator. The number 3 is the square of the diagonal of a unit cube; 2 and 5 are the factors of 10.

$e = 2^{-16} \cdot 3^{14} \cdot 5^{-16}$
$= 3^{14} \cdot 10^{-16}$
$= 4.782969 \cdot 10^{10}$
$= 4.774 \pm \cdot 10^{10}$ Millikan's value of the electron charge.
$= h = 2^{-30} \cdot 3^{8} \cdot 5^{-30}$
$= 3^{8} \cdot 10^{-30}$
$= 6.561 \cdot 10^{-27}$
$= 6.55 \pm$ Planck's Constant.
$a = 2^{-14} \cdot 3^{12} \cdot 5^{-14}$
$= 3^{12} \cdot 10^{-14}$
$= 5.31441 \cdot 10^{-9}$
$= 5.2 \pm \cdot 10^{-9}$ Bohr's fundamental radius of the electron orbit in hydrogen.
$c = 2^{10} \cdot 3 \cdot 5^{10}$
$= 3 \cdot 10^{10}$
$= 2.9986 \pm 10^{10}$ experimental velocity of light.
$M_0 = 2^{-28} \cdot 3^{2} \cdot 5^{-28}$
$= 3^{2} \cdot 10^{-28}$ the mass of the electron at low velocity.
$G = 2^{-6} \cdot 3^{-1} \cdot 5^{-7}$
$= 20 \cdot 3^{-1} \cdot 10^{-8}$
$= 6.66\frac{2}{3} \cdot 10^{-8}$
$= 6.6607 \pm \cdot 10^{-8}$ Newton's gravitational constant.
$K = 2^{-11} \cdot 3^{-6} \cdot 5^{-11}$
$= 1.37 + \cdot 10^{-16}$ Baltzmann's gas constant, or the ordinary gas constant divided by N, the number of molecules in a gram-molecule."

CARBON DIOXIDE CHECKS PNEUMONIA.

The collapse of a lung that sometimes follows a surgical operation and ends in death by pneumonia can be prevented by giving the patient carbon dioxide to breathe. This gas, the normal waste-product of respiration, induces deep breathing and so expands the lung again, preventing its becoming clogged with fluid, or, if the fatal blocking has already begun, clearing it up again.

Report of a cooperative research undertaken demonstrating these points was made before the Thirteenth International Physiological Congress. Dogs suffering from severe pulmonary collapses and accompanying pneumonia had their breathing stimulated with "doses" of carbon dioxide. X-ray photographs showed how the collapsed lungs were redistended and the pneumonia cleared up. Evidence from patients shows that pneumonia following influenza can be cured by this inhalation. It likewise saves many hundreds of lives each year, of persons asphyxiated by illuminating gas and automobile fumes.

The experiments were conducted by Doctors Pol N. Coryllos and G. L. Birnbaum of New York City, and Doctors Yandell H. Henderson, H. W. Haggard and E. M. Radloff of Yale University.—*Science News-Letter*.

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